THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

ART. LIV.—*Notes on American Earthquakes, No.* 14; by C. G. ROCKWOOD, JR., Princeton, N. J.

IN this article, as in former ones of the series, I give a summary of the information which has come into my hands in regard to earthquakes which occurred during the preceding year in North or South America and the adjacent waters. The information has been gathered from various sources, largely from the Monthly Weather Review of the U. S. Signal Service, and from current newspapers; but I have also been fortunate in receiving a greater number than usual of manuscript reports, mostly relating to the shock of Aug. 10. For many of these my thanks are due to Cleveland Abbé of the Signal Service, and especially to W. M. Davis of Harvard College, who kindly put into my hands a large amount of matter, both manuscript and printed, which he had collected. The persons, whose letters to these two gentlemen I am reaping the benefit of, are too numerous to be mentioned here by name, but putting their contributions with my own collection, I find that I have at command about one hundred and fifty direct manuscript reports on the earthquake of Aug. 10, besides a very large amount of newspaper cuttings. For other reports I am, as heretofore, indebted to J. M. Batchelder of Cambridge, Mass., and to Charles Carpmael of Toronto, Superintendent of the Canadian Meteorological Service.

As in former notes, when a shock is recorded on the authority of a single report, the source of the information is indicated,

and a few items, which were regarded as somewhat uncertain, are printed in smaller type. The division of the day into twenty-four hours is again employed.

An attempt has also been made in these notes to distinguish the shocks according to the degree of intensity. For that purpose a scale was provisionally adopted, with reference to which the adjective indicating intensity was selected, this selection being guided, whenever possible, by the statements of the phenomena observed rather than by the mental impression of the observer. Thus an earthquake called by the newspapers "severe" may perhaps be found characterized here as "light" because only causing the phenomena which mark that degree. The scale employed is as follows:

I. *Very light:*—Noticed by a few persons but not generally felt.

II. *Light:*—Felt by the majority of persons, rattling windows and crockery.

III. *Moderate:*—Sufficient to set suspended objects, as chandeliers, etc., swinging, or to overthrow light objects favorably placed.

IV. *Strong:*—Sufficient to crack the plaster in houses or to throw down bricks from chimneys.

V. *Severe:*—Overthrowing chimneys or walls and injuring some buildings.

VI. *Destructive:*—Causing general destruction of buildings, etc.

This scale is adopted for the purposes of the present article, but it is quite probable that considerations of uniformity with European observers may lead to the use of the Rossi-Forel Scale in future papers.

1884.

Jan. 3.—At $20^h\ 40^m$ a *light* shock occurred at Portland, Oregon; duration about two seconds; vibration southeast to northwest.—*U. S. Weath. Rev.*

Jan. 4.—At $11^h\ 56^m$ a *very light* shock at Los Angeles, California.—*U. S. Weath. Rev.*

Jan. 14.—At Montevideo, Uruguay, a little after $7^h\ 30^m$ the sea suddenly fell so that bathers were able to reach bottom where before there had been a depth of three metres. Immediately a wave, coming from the south-southwest, rolled upon the shore, raising the water about 1.50^m above its mean level. The phenomenon was confined to the immediate vicinity of Montevideo, not being noticed at Buenos Ayres on the opposite side of the estuary.—*Comptes Rendus*, Feb., 1884.

Jan. 18.—At 2^h a *moderate* earthquake occurred at Contoocook, New Hampshire, and vicinity.

Jan. 18.—At about 8^h two *light* shocks were felt on the southern coast of North Carolina. They were reported from Wilmington, New River Inlet, Fort Macon, and Beaufort, and ten miles east of Newberne, and also along the railroad connecting Newberne and Beaufort. They were sufficient to rattle windows and crockery. At Fort Macon a rumbling sound was heard, the duration was stated as three or four seconds, and the direction southwest to northeast.

Jan. 25.—Assistant George Davidson of the U. S. Coast Survey reported from San Francisco that at $19^h\ 24^m$, "Earthquake waves were indicated by the levels of the astronomical instruments of the observatory. The amplitude of each vibration was three seconds of arc in six seconds of time and they continued for twenty minutes."

Jan. 27.—At $23^h\ 30^m$ a *moderate* earthquake occurred in Humboldt County, Cal. Two shocks were felt, the first at the time above stated, the second, a very light one, about five minutes later. They were preceded and followed by a roaring sound, and were reported from Eureka, Hydesville, and Cape Mendocino. At the latter place the first shock was sufficient to shake buildings perceptibly and to displace light articles. The direction was variously stated.

Jan. 29.—Three distinct *light* shocks at Rothesay, nine miles from St. Johns, N. B. The hour not stated.—*N. Y. Times.*

Feb. 15.—About 6^h a *very light* shock at Caledonia, Missouri, reported by R. F. Chew in the Saint Louis "Globe Democrat," Feb. 20, '84.

Feb. 16.—At 9^h a *very light* earthquake at Point des Monts, Quebec.—*Canadian Meteorol. Serv.*

March 2.—At $10^h\ 20^m$ a *moderate* shock in Orchilla Harbor, in the Caribbean Sea, and another lighter one at 4^h on March 4 at the same place; reported by Captain Holt of the ship "David Stewart."—*J. M. B.*

March 15.—At $3^h\ 7^m$ a *very light* shock at San Francisco, Cal., preceded by a loud rumbling noise.—*N. Y. Times.*

March 17.—At 14^h a *light* shock at North Platte, Nebraska.—*U. S. Weath. Rev.*

March 18.—Between $13^h\ 30^m$ and $13^h\ 45^m$ a *moderate* earthquake occurred in Southeastern Newfoundland. It extended from St. John, where it was only slightly felt, northwestward to Trinity, a distance of about sixty-five miles, being reported in the intervening country from Hearts Content, Harbor Grace, Roberts, Brigus Bay, and Holyrood. The direction was north to south.

March 25.—At $16^h\ 40^m$ a *severe* earthquake shock occurred at San Francisco, Cal., and vicinity, followed by a second somewhat

lighter shock at $17^h\ 17^m$. It was felt along the coast from Santa Cruz to Petaluma, a distance of about a hundred miles. The first shock lasted about five seconds, the other about two seconds. The direction was north and south. In San Francisco some houses were seriously injured, the walls being cracked so as to render them unsafe. It was severely felt in Oakland and Berkeley on the east side of San Francisco Bay.

March 29.—In the evening a *light* shock reported in Accomac County, Virginia. —*N. Y. Times.*

March 31.—At 5^h a *light* shock was felt at Milledgeville, Georgia.—*U. S. Weath. Rev.*

March 31.—At 13^h three *very light* shocks reported by J. W. Hammit at College Hill, Hamilton County, Ohio.—*U. S. Weath. Rev.*

April 6.—At $6^h\ 20^m$ a *very light* shock felt at Eureka and Hydesville, Humboldt County, Cal.

April 8 and 11.—*Very light* shocks in the morning at Eureka, Cal.—*U. S. Weath. Rev.*

April 11.—At $14^h\ 10^m$ a *moderate* shock at Carson City and Virginia City, Nevada; duration three seconds; vibration northwest to southeast.

April 17.—At $21^h\ 10^m$ a *light* shock at Oakland, Cal., accompanied by a rumbling noise; vibration northwest to southeast.—*U. S. Weath. Rev.*

April 20.—At $11^h\ 30^m$ a *very light* shock at Oakland, Cal.—*U. S. Weath. Rev.*

April 21.—At 9^h, the schooner "M. A. Nutter," when in lat. 21° 6′ N., long. 61° 44′ W. "was shaken from stem to stern by the shock of an earthquake, apparently from the westward." The position given is in deep water (about 3000 fathoms), about 200 miles northeast of Sombrero, Windward Islands.

April 30.—At $6^h\ 46^m$, at Ogreeta, Cherokee County, North Carolina, a low rumbling sound of earthquake was heard, apparently from the north. No tremor was reported.—*U. S. Weath. Rev.*

June 6.—At 1^h two *strong* shocks were felt at Red Bluff, California, each of about one second's duration and with an interval of three or four seconds. The shock caused the wall of a brick building to crack. The direction was east to west.

June 12.—At $8^h\ 43^m$ a *strong* shock is reported by Capt. C. F. Swan to have been felt on the ship "City of Brooklyn" when in lat. 40° 24′ N., long. 125° 50′ W., being in the Pacific Ocean, about 75 miles west of Cape Mendocino, Cal. It "caused the vessel to shake as though she had struck a reef."

June 16.—At $10^h\ 48^m$ a shock was felt at Los Angeles, Cal., vibrations north to south; duration about two seconds.—*U. S. Weath. Rev.*

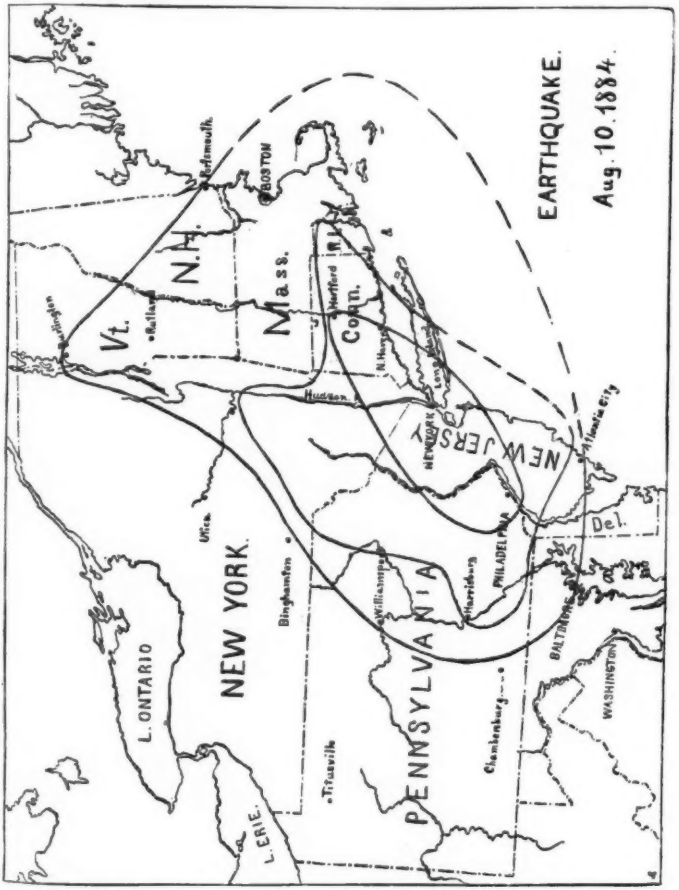
July 15.—About daylight a *very light* shock reported at San Francisco, Cal.; vibration east to west.—*U. S. Weath. Rev.*

Aug. 4.—About 1^h three *very light* shocks at Santa Barbara, Cal. A very light shock also on the night of the 2d–3d.—*U. S. Weath. Rev.*

Aug. 8.—About 23^h a *very light* shock at Tuckernuck, near Nantucket, which was reported to me by Prof. E. S. Morse, of Salem, Mass.

Aug. 10.—About 14^h 7.3^m a *strong* earthquake occurred in New England and the Middle States, a preliminary notice of which has already appeared in this Journal (xxviii, 242).

In investigating the area affected by this shock, 215 reporting stations were marked upon the map, a reduced copy of which accompanies these notes. The stations were marked in



such a way as to indicate the intensity at each, according to the adopted scale, as inferred from the reported phenomena, and three curves of intensity were drawn. The largest curve includes all stations reporting except Titusville, Pa. The next curve includes all those where the intensity reached III, except Boston, Mass., and Rutland, Vt. The inner curve includes all those reaching IV. The only places where the reported intensity reached V were Jamaica and Amityville in the western part of Long Island. At Jamaica it was stated that "the walls of the Presbyterian Sunday School were cracked in two places, the openings being from one to two inches in width and extending from the roof to the foundation." At Amityville it was reported that "a large mirror which reached from the ceiling to the floor was cracked from the top to the bottom and the walls of the room were cracked in two places. A broom handle can be laid in the cracks in the walls."

The boundary of the largest area passes from the coast near Portsmouth, N. H., to Burlington, Vt., then turning sharply southwest passes about midway between Utica and Schenectady, N. Y., a little east of Binghamton, N. Y., west of Williamsport, Pa., east of Chambersburg, Pa., south of Mechanicstown and Baltimore, Md., and so eastward to the coast again at Atlantic City, N. J., enclosing a land area of about 70,000 square miles. The area of intensity IV is nearly elliptical, its longer axis extending from Hartford, Conn., to West Chester, Pa., and having its centre near New York, being about 200 miles long by 70 miles wide. The long axis of this ellipse is closely parallel to the general direction of the Appalachian chain in this region. At thirty places within this area, fallen bricks, cracked plaster, etc., testified to the power of the earthquake. The shock was reported from Titusville in northwestern Pennsylvania, but was apparently not felt at any other place in that direction beyond Williamsport.

The time observations which appear most reliable are given in the following table:

Place.	Observer.	Time after 14 h.
Shelter Island, (L. I.) N. Y.	Prof. Horsford.	$6^m\ 30^s$.
Seabright, N. J.	(?)	$6^m\ 50^s$.
Asbury Park, N. J.	W. D. Johnson.	7^m.
Point Pleasant, N. J.	Prof. H. A. Newton.	$7^m\ 3^s$ to $7^m\ 7^s \pm 2$ or 3^s.
Morristown, N. J.	C. G. Rockwood.	7^m.
Princeton, N. J.	Prof. C. A. Young.	$7^m\ 30^s \pm 4$ or 5^s.
Germantown, Pa.	W. F. Burr. P. M. Reese.	$7^m\ 20^s$ to $7^m\ 30^s \pm 2^s$.
Brooklyn Heights, N. Y.	S. McElroy.	$8^m\ 30^s$.
Stone Ridge, N. Y.	Prof. I. E. Hasbrouck.	8^m.
New Haven, Conn.	L. Waldo.	$7^m\ 25^s$.
Harvard College.	Prof. Pickering.	$7^m\ 15^s$.

These do not indicate with any certainty a progressive motion from any centre. Assuming the shock, therefore, to have been practically simultaneous at these stations, the mean of these times, or $14^h\ 7^m\ 18^s$, would be the time of the beginning of the earthquake as nearly as it can be ascertained.

The directions reported at fifty-nine stations were plotted and examined. They are as follows:

Northwest and southeast	7
North and south	19
Northeast and southwest	19
East and west	14

The only inference that can be drawn from this statement is that the propagation was in a northeast-southwest direction or the reverse, since the number of northwest-southeast observations is notably less than the others. An examination of the map at once indicates that the cause of this earthquake is to be sought in the vicinity of New York City. The center of the inner curve falls in northeastern New Jersey, where are several dykes of trap rock, prominent among which is the one forming the Palisades, on the west bank of the lower Hudson, and which is continued southward in Bergen Hill to its end in Staten Island. Nor is the presence of these trap dykes the only indication that the vicinity of New York Bay has been a disturbed area in past geological time. The fact that here is the lowest part of the grand Appalachian chain, which reaches much greater elevations in the Catskills and the Green Mountains to the north, and in the Alleghanies to the south; the deflection of the plumb line, which here is toward the ocean instead of toward the mountains; the presence of the bay itself, intensified by the strange depression or valley in the ocean bottom extending seaward from Sandy Hook, as shown in the relief model exhibited by Professor Hilgard at the Philadelphia meeting of the American Association last summer; the comparative frequency of slight earthquakes in this neighborhood; all these point to a condition of the subjacent strata favorable to the occurrence of fractures and faults, which would give rise to the surface phenomena of an earthquake. While the observations in the present case are not sufficiently precise to locate such a fracture exactly, the general inference that this earthquake was due to some rupture of the strata underlying the immediate neighborhood of New York seems sufficiently well substantiated. The observations on direction pointing to a more decided vibration in a northeast-southwest direction, and the longer axis of the smaller intensity curve trending in the same general direction, would indicate that the line of the fracture was northwest and southeast, a direction which is at right angles to the trend of the

trap dykes, as also to the strike of the sedimentary strata, and parallel to that of the submarine valley spoken of above.

Much time has already been given to the study of the material gathered in regard to this earthquake, the general conclusions of which have been stated, and the hope is still entertained of publishing in due time a more detailed discussion accompanied by a larger map.

There were sundry reports of light succeeding shocks at various hours on the 11th, but none were confirmed by two observers, and all were apparently due to the excited imagination of the public.

Aug. 24.—At $19^h\ 45^m$ a *light* earthquake, rattling windows and accompanied by a low rumbling sound, occurred at Knoxville, Tennessee, and vicinity.

Sept. 10.—An earthquake at Lima, Peru, called in newspaper reports "a strong shock," but no damage reported.—*J. M. B.*

Sept. 19.—At $14^h\ 14{\cdot}2^m$ central standard time, a *moderate* earthquake was felt in Ohio and Indiana and portions of the

Earthquake, Sept. 19, 1884. • Places reporting. + Greater intensity.

adjacent States. From the accompanying plan formed by marking on the map the positions of one hundred and two places where it was reported to have been felt, its principal area is seen to be approximately defined by the following chain of cities, viz: Louisville, Ky., Parkersburg and Wheeling, West Va., London, Ont., Bay City and Grand Rapids, Mich., Michigan City and Lafayette, Ind. A curved line enclosing these places would include a nearly circular area, with a diameter of about four hundred miles and whose center is a little east of Lima, Ohio; and within this area the reporting stations are seen to be thickly crowded. Reports from Cedar Rapids and Dubuque, Iowa, mention tremors noticed by a few persons there, and corresponding approximately in time with this shock; while a few persons claimed to have felt it faintly in Washington, D. C. Among the latter were workmen on the top of the Washington Monument, at that time about 500 feet high. These last places are far outside of the boundaries given above. Within these lines the shock was evidently not of equal intensity in all places. At Indianapolis and at Vevay, Lawrenceburgh, Connersville and Winchester, all in the southeastern corner of Indiana; at Cincinnati, Urbana, Findlay and Cecil in Western Ohio; at Columbus, Millersburg and Cleveland in Central and Northern Ohio; as also at Parkersburg, West Va. and at East Saginaw, Mich., there were reports of swaying chandeliers, displaced furniture, etc., indicating an intensity reaching III. of our scale. All these places except the last two are in the middle portion of the disturbed area, and would be within an elliptical area with a major axis of about 300 miles directed approximately northeast and southwest, and a minor axis about half as great. This inner curve is not symmetrically placed with respect to the outer one, its center falling about thirty miles south of that of the larger area and near the town of Belle Fontaine, Ohio. Outside of this area, except at the two places mentioned, the reported phenomena nowhere indicate an intensity greater than II of our scale.

The time given above is the mean of twelve reports in which the time given was directly stated to be either "standard" or "local." These are contained in the annexed table, in which, for the last eight places, the dates have been reduced from local time to the standard time of 90° west longitude.

	h. m.		h. m.
Shelbyville, Ind.	2.15 P. M.	Columbus, O.	2.14 P. M.
Metamora, Ind.	2.15	Cleveland, O.	2.14
Archbold, O.	2.13	Newark, O.	2.15
Coshocton, O.	2.15	Detroit, Mich.	2.13
Indianapolis, Ind.	2.14	E. Saginaw, Mich.	2.11
Toledo, O.	2.16		
Cincinnati, O.	2.15	Mean,	2.14.2

At many other places time was reported but without indicating to what standard it was referred.

At many places two or three distinct vibrations were noted, and the duration was variously estimated from three to thirty seconds. Notes of the direction of vibration are given at comparatively few places and present nothing of interest. At Columbus, O., chandeliers were observed to sway from north to south, the motion continuing for at least two minutes.

In seeking for a possible connection between this earthquake and the geology of the region, we at once meet with a very suggestive fact. Crossing the western part of Ohio is an anticlinal, known in the geology of the State as the Cincinnati arch.* Its axis or crest is traced from south to north through Tennessee and Kentucky, crosses the Ohio River a little east of Cincinnati, extends in a direction somewhat east of north, passing near and a little east of Belle Fontaine, and reaches the lake shore between Toledo and Sandusky, some fifteen or twenty miles east of the former. It probably finds its continuation in some islands in Lake Erie. Its bearing is nearly parallel to that of the folds of the Alleghanies. The rocks composing this arch are the Lower Silurian limestones, especially those known as the Cincinnati group, which occupy the crown as far as Dayton, while farther north these are overlaid by the Niagara and later deposits. Professor Newberry† regards this arch as having been upraised between the Lower and Upper Silurian ages, but as having continued to be a line of disturbance through several succeeding geological ages.

I have thought it worth while to state thus some of the facts in regard to this Cincinnati arch, because its axis crosses so exactly over the centers both of the larger area of disturbance and of the smaller area of increased intensity of this earthquake as described above, and the direction of this axis approaches so nearly to that of the long axis of the smaller earthquake area, that a physical connection between the two phenomena is at once suggested. It is natural to infer that this anticlinal arch is still in a state of strain and that the earthquake of September 19th was the direct result of some giving way or snap of the strata forming it, causing a new fault somewhere near Belle Fontaine. It would be interesting in this connection to know if there have been any signs of recent changes of level in that region, or anything else to indicate that the upheaval of this arch may be still in slow progress.

Sept. 21.—Between 22^h and 23^h *light* shocks were felt at New Tacoma, Washington Ter.—*U. S. Weath. Rev.*

Sept. 26.—At $22^h\ 53^m$ a *light* shock was felt at Fort Yuma, Arizona, duration ten seconds, vibration south to north. An-

* Geological Survey of Ohio, vol. i.
† Geol. Surv. of Ohio, vol. i, pp. 103, 106.

other very light shock was felt about 3^h of the 27th.—*U. S. Weath. Rev.*

Oct. 2.—Two *light* shocks occurred at Rivas, Nicaragua, the first at $14^h\ 32^m$, of two seconds duration, the second after 15^h of about three seconds duration. The latter was also reported as strongly felt at San Juan del Sur at 16^h. The district of Rivas, where these places are situated, occupies the country, about thirty miles wide, between Lake Nicaragua and the Pacific Ocean.

Oct. 10.—In the early morning a *very light* shock at Roxbury and West Newton, Mass., and vicinity.—*J. M. B.*

Oct. 22.—At $15^h\ 34^m$ a *light* shock at Los Angeles, Cal.—*U. S. Weath. Rev.*

Oct. 24.—At $0^h\ 15^m$ a *very light* shock at Huntingdon, Quebec. —*Canadian Met. Serv.*

Oct. 26.—Shortly after 20^h a *very light* shock was felt at Nashua, N. H. There was a noise as of a heavy explosion followed by a low rumbling sound. The general direction of the tremor was from southwest to northeast, and it continued four or five seconds.—*J. M. B.*

Nov. 4.—The ship "Occidental" reported that at 18^h, when 150 miles off Cape Mendocino, Cal., three shocks of earthquake were felt, followed a few hours later by two heavier ones.—*U. S. Weath. Rev.*

Nov. 5.—A *destructive* earthquake occurred on the isthmus of Panama, in which Aquadas and Pacoria suffered severely, churches, public edifices and private houses being overthrown, with damages estimated from $250,000 to $400,000.—*Newark* (*N. J.*) *Daily Advertiser.*

Nov. 6.—Despatches from Buenaventura, States of Colombia, report that a *severe* earthquake was felt on the night of the 6th at Cali and other towns in the Southern States. The church of San Pedro at Cali was wrecked and other buildings suffered severely.

It is possible that the last two items may refer to the same occurrence. The hour was not stated in either case.

Nov. 9.—About 2^h a *strong* earthquake was felt at Fort Bridger, Wyoming, at Salt Lake City, Utah, and at Paris, Idaho. At Fort Bridger "telegraph wires swung perceptibly," the duration was five to ten seconds and the direction west to east. At Paris six shocks were reported between 2^h and 4^h. Here also "considerable damage to houses is reported and people were affected by sea-sickness." The notes in regard to Salt Lake City and Paris are from the Kansas City Review of Science, where the date is given *Nov.* 10. But both accounts seem evidently to refer to the same occurrence which is known to have occurred on Nov. 9 at Fort Bridger.

Nov. 12.—About $19^h\ 50^m$ a *light* earthquake occurred in Southern New Hampshire, being reported from Concord, Hop-

kinton, Bradford and Warner in Merrimack County, and Hillsborough and Antrim in Hillsborough County.

Nov. 12.—The self-registering tide guage at Saucelito, Cal., recorded a series of waves probably due to a submarine earthquake. They are thus described in the San Francisco Evening Bulletin of Dec. 13. "They commenced at eight o'clock in the morning and ended at eleven. There are nine well-marked crests in two and a half hours or only seventeen minutes apart. They are only two or three inches in height but maintain the characteristic earthquake features, in plain contrast with the breaking bar markings, which are very sharp and frequent. It would appear from the height and length of the waves that this submarine earthquake took place near our coast and was not violent."

Nov. 13.—The so-called earthquake reported on this date in Essex County, Ontario, was caused by an explosion of powder at Toledo, Ohio.

Nov. 21.—In the evening several places on both sides of the St. Lawrence River; between St. Flavie, Kamouraska Co., and Gaspé, a distance of about 250 miles, were visited by a *light* earthquake. The vibration lasted 45 or 50 seconds, but did no damage, although creating alarm.

Nov. 22.—At 7^h 13^m a *destructive* earthquake occurred at Lima, Peru, and vicinity. The motion was from southwest to northeast. At Callao portions of the cliff were shaken down upon the beach. The walls of many houses were cracked and some were shaken down. At Chorillos a series of cracks were opened nine yards from the edge of the cliff.

Nov. 23.—At 0^h 30^m a *strong* earthquake occurred in New Hampshire, Eastern Massachusetts and Connecticut. At Concord, N. H., a light shock was followed by a heavier one sixteen minutes later, direction west to east, accompanied by a rumbling noise loud enough to awaken people. At Henniker, N. H., the foundation of a boiler was displaced. It was "extensively felt in that part of the State." It was reported as lightly but distinctly felt at Plymouth, Grafton Co., N. H., at New Ipswich and Cliftondale, Essex Co., at Cambridge and at Holden, Worcester Co., Mass., and at Hartford and Mansfield, Conn. At the last-named place seven or eight shocks were noted in rapid succession, increasing in intensity from first to last. The time of the occurrence, a half hour after midnight, will probably account for its not having been more generally noticed at intervening places.

Nov. 29.—About 23^h a *light* shock occurred in Western Tennessee, reported from Memphis, Covington and Dyersburg. The direction was generally stated as west to east or southwest to northeast, duration variously given from five seconds to a minute. It was accompanied by a rumbling noise.

Dec. 4.—At 0^h 18^m a *very light* shock at Northampton, Mass.—*Bull. N. Eng. Met. Soc.*

Dec. 17.—At about 2^h a *light* shock was felt at Laconia and Center Harbor, Belknap Co., N. H.

The above list contains fifty-four items not counting the one of Nov. 13, of which seven are in small type. They may be geographically classified thus:

Canadian Provinces	5
New England	9
Atlantic States	5
Mississippi Valley	7
Pacific Coast	21
West Indies	2
Central America and Colombia	3
Peru	2
Uruguay	1
	55
Deduct for Aug. 10, counted twice	1
	54

By seasons they are classified thus:

Winter, 12 (Dec., 2; Jan., 8; Feb. 2); Spring, 15 (Mar., 8; Apr., 7; May, 0); Summer, 8 (June, 4; July, 0; Aug., 4); Autumn, 19 (Sept., 4; Oct., 5; Nov., 10); Spring and Summer together, 23; Autumn and Winter together, 31.

The following localities were shaken on two or more days, viz: Los Angeles, Cal., Jan. 4, Jan. 16, Oct. 22; San Francisco, Jan. 25, Mar. 15, 25, July 15, Nov. 12; Oakland, Cal., Mar. 25, April 17, 20; Eureka, Cal., Jan. 27, April 6, 8, 11; Concord, N. H., Aug. 10, Nov. 12, 23.

The only shocks causing much damage were Nov. 5, Panama; Nov. 6, Colombia; Nov. 22, Lima, and Aug. 10, Middle States.

Princeton, March 28, 1885.

Art. LV.—*Taconic Rocks and Stratigraphy;* by James D. Dana.

[Continued from page 222.]

V. *Metamorphism and Mineral Constitution in the Taconic Region, gradational from West to East and from North to South.*

The succession in the different lithological areas exhibited on the map of the southern portion of the Taconic region (published with the preceding part of this paper) is as follows, beginning on the west:

(1.) Winchell's Ridge of schist and other small ridges in Copake north of it.

(2.) The western belt of limestone, passing through Copake and Millerton.

(3.) The limestone area in Salisbury, with its isolated schist ridges, extending eastward to the Housatonic River and continued across the river far into Canaan (the river being the political boundary between the two towns).

(4.) Schist to the eastward of the outcropping limestone in

Canaan mountain, and probably part of that of other eastern ridges.

The underlying position of the limestone was proved by the fact of universal *eastward dips* in the schist and limestone on the *west* side of the various schist ridges and the occurrence of *westward dips* along the *east* side of Mt. Washington, the two concurrent facts proving that the mountain is synclinal in structure; and also by stratigraphical sections from other ridges. In view of this underlying position over the whole breadth of the region from Canaan mountain to Winchell mountain, and the actual continuity of the limestone over Salisbury and Canaan, and over the adjoining towns north in Massachusetts, it was concluded that the limestone, with some intercalations of schist, was one continuous stratum or formation. By similar evidence it was shown that the overlying schist belonged to one continuous stratum.

I have given no descriptions of the iron-ore deposits along the marginal portions of the limestone areas because they are of secondary origin. But it is to be noted that if the view of their origin which I believe to be sustained by the facts* is correct, they prove that during the transition from the making of the limestone to that of earthy sedimentary deposition there were in some parts conditions favorable to ferriferous depositions over the calcareous sediment; in other words, there were great sea-border marshes or basins to receive contributions from iron-bearing waters. These depositions, however, were local, as such always are, and are very far from indicating the presence of a universal stratum of more or less ferriferous limestone (with some included iron carbonate) adjoining the stratum or strata of schist. Yet it is true that the adjoining portion of the limestone, sometimes for scores of feet in thickness, is generally very impure from mixture with the materials of the schist.

The several ore-pits are designated on the map by letters; I give here their names, adding an asterisk to those that were worked in 1884.

In Salisbury: *b*, Ore-Hill*; *c*, Chatfield*; *d*, Porter; *e*, Forbes*; *f*, Clarke's; *g*, a partial opening; *h*, Scoville's, the ore mostly manganese oxide, and accompanied sparingly by the mineral Scovillite; *i*, Camp's. In Sheffield: *j*, Little's. In New York: *k*, Copake*, or Miles's; *l*, Weed's*; *m*, Couch; *n*, Mt. Riga*, or Cheaver; *o* (in Ancram), Reynolds; *a*, Millerton or Maltby.*

We have now to consider *the variations in degree of metamorphism*, and *in mineral constitution* in these two strata on going over the region from west to east and from north to south.

* This Journal, xxviii, 398, Nov. 1884.

1. The Schist with the Quartzyte.

The schist of the region varies from very fine-grained thin-fissile glossy hydromica (or sericite) schist to coarsish mica schist containing garnets and staurolites; and toward the east, to arenaceous or quartzytic mica schist without staurolite, and mostly without garnets. Each of the rocks contains disseminated magnetite, and often pyrite, and sometimes these minerals are in distinct crystals. Minute brown or brownish tourmalines also are found sparingly in all the kinds.

The term *quartzose* or *quartzytic* is used beyond synonymously with arenaceous, it referring to the occurrence of quartz grains in the schist and not to vein quartz. In the hydromica and mica schist the grains lie in small, thin or thick, interrupted layers between the leaves of the schist, as if deposited like the interrupted laminations of sand in some river-valley clays; they vary in length from an inch to many feet, and in thickness from $\frac{1}{100}$th of an inch and less, to $\frac{1}{2}$ inch or more; they are smallest in the finest of the slate.

The facts mentioned below are from both macroscopic and microscopic examinations.

A. *Section through the Southern part of Mt. Washington from Winchell Mountain to Canaan Mountain.*

1. *Mt. Winchell.*—At the summit of Mt. Winchell the rock is thin-fissile hydromica (or sericite) schist. It consists chiefly of muscovite mica in minute scales about $\frac{1}{200}$ to $\frac{1}{300}$ inch across, and has the fusibility of the mica. Biotite mica is rare. Quartz grains are sparingly present in delicate interlaminations, as seen in a transverse section. Minute tourmalines rather rare. Chlorite not observed either macroscopically or in the thin slices. At the eastern foot of Mt. Winchell the rock is the same, but slightly coarser and often a little crumpled (from pressure). Muscovite scales are mostly $\frac{1}{100}$ to $\frac{1}{200}$ inch across; some biotite scales occur $\frac{1}{50}$ to $\frac{1}{100}$ inch across and generally grouped.

2. *West side of Mt. Washington.*—North of Millerton—about a mile east of the base of Winchell mountain—the rock is a very fine-grained mica schist, consisting chiefly of muscovite, with little chlorite; muscovite scales mostly $\frac{1}{50}$ to $\frac{1}{200}$ inch; the biotite scales larger. Quartz grains in thin interlamination often making up a fourth or more of the thickness. Garnets are few and small, or absent; orthoclase feldspar is found in occasional grains; staurolites are absent.

3. *East side of Mt. Washington, in Salisbury.*—The schist is a coarsish muscovite mica schist with some biotite and usually no chlorite; muscovite scales about $\frac{1}{100}$ to $\frac{1}{30}$ inch, and biotite

$\frac{1}{16}$ to $\frac{1}{4}$ inch. Interlaminations of quartz generally make more than a fourth of the thickness. Garnets are abundant, $\frac{1}{12}$ to $\frac{1}{8}$ inch. Staurolite crystals abundant in some portions, $\frac{1}{8}$ to $\frac{1}{4}$ inch long and less. Orthoclase sparingly present. Minute tourmalines of occasional occurrence both in the quartz seams and the micaceous portion.

4. *Three miles east of Mt. Washington on the eastern border of Salisbury.*—The schist is similar to the preceding but somewhat coarser; muscovite scales $\frac{1}{16}$ inch and less; biotite more common than in the Mt. Washington schist. Interlaminations of quartz often make half the thickness of the schist. Garnets abundant and staurolites common in many layers, $\frac{1}{3}$ to $\frac{2}{3}$ inch long, mostly $\frac{1}{2}$ inch.

5. *East of the Housatonic (and of Salisbury) in Canaan.*—The schist is partly normal mica schist, but generally a very arenaceous or quartzytic mica schist, the quartz $\frac{3}{4}$ths to $\frac{9}{10}$ths and more of the material; the mica mostly biotite, but in some small portions muscovite predominates. Garnets are few and small, or absent.

Quartzyte in strata occurs with the schist, both the fragile bedded kind and the hard massive. It consists of quartz grains with some orthoclase and microcline, often some mica, not unfrequently minute tourmalines.

The schist and quartzyte contain *no* staurolites. This fact comports with the constitution of this mineral, which ordinarily contains less than 31 per cent of silica and over 48 of alumina.

Going farther east in Canaan mountain the schist changes to a normal mica schist.

B. *Section through the northern part of Mt. Washington from Copake through Sheffield commencing at the west.*

1. *In Copake, New York.*—The schist of the small ridges north of Winchell Mountain is a very thin fissile hydromica (or sericite) schist, like the Winchell slate, but of finer grain; looks like a smooth, glossy roofing slate. Contains no garnets.

2. *West side of Mount Washington, near Copake Furnace.*—The rock is a greenish or chloritic hydromica schist, with also mica schist. It is sparingly garnetiferous; without staurolites.

3. *East side of Mount Washington in Sheffield.*—The schist is like that on the west side, but it is coarser, and a larger part is true mica schist. It contains garnets, but no staurolites were found. Minute tourmalines occur in it.

4. *Three miles east of Mt. Washington near the village of Sheffield, west of the Housatonic.*—The schist is a coarsish mica schist, garnetiferous, and containing small staurolites. It resembles the schist of the southern part of the east side of Mt. Washington in its degree of fineness and in its staurolites, and

is less coarse than that directly south in Salisbury, near Lime-rock Station.

5. *East of Sheffield village, and of the Housatonic River.*—The schist is the same *arenaceous* mica schist that occurs to the south in Canaan, and, as there, it alternates with, and often graduates into a great formation of quartzyte. North of Sheffield village, west of the Housatonic, the same quartzyte, partly micaceous, constitutes the south end of a ridge that extends north into Great Barrington.

C. *Conclusion.*

The facts here reviewed relate, it should be remembered, to a single stratum, that overlying the limestone. Since the change from west to east is so strongly marked even in Mt. Washington, only five miles broad, and in one and the same lower portion of the schist, or that directly over the limestone, the facts have special interest.

The change is of two kinds—(1) *a change in degree of metamorphism;* (2) *a change in mineral constitution.*

(1) *An increase eastward in intensity of metamorphic action.* This is manifested—

(*a*) In the gradual increase in size of the scales of mica; (*b*) in the change from hydrous mica to ordinary mica in the Mt. Washington schists, and in the occurrence of the latter alone east of Mt. Washington; (*c*) in the absence of chlorite (another hydrous mineral) from the southern half of *eastern* Mt. Washington and its absence from the schist of ridges farther east; (*d*) in the increasing size of the garnets and staurolites on going eastward over Salisbury.

(2) The *change in mineral constitution*, beyond what has been stated in the preceding paragraph, is as follows:

a. Biotite mica, which is very sparingly present in the Winchell slates, increases in amount in eastern Salisbury, and is much the most common kind in the arenaceous schists to the eastward.

b. Granular quartz, which is very sparingly present in the Winchell slates, gradually increases in amount eastward, is rather abundant in the southern part of eastern Mt. Washington, and still more so in eastern Salisbury; and east of the Housatonic for a breadth of two miles or more it is the preponderating constituent in the mica schist and composes quartzyte strata.

c. Tourmaline in minute crystals is sparingly present in the western schists and much less sparingly in the quartzyte and quartzytic mica schist to the eastward.

d. Garnets, which are not present in the Winchell slates,

occur very small in western Mt. Washington, and increase in abundance and size to the Housatonic; but are few and small in the arenaceous schist east of the Housatonic.

e. Staurolites occur of very small size in the southern half of eastern Mt. Washington, and are, on an average, twice longer in eastern Salisbury. In the northern half of Mt. Washington, staurolites have not been found, but they occur in the coarsish mica schist three miles farther east. (This interval of three miles is occupied by limestone so that no nearer observation is possible.)

f. Orthoclase is very sparingly present in the hydromica (or sericite) schist to the west; but is less rare in the mica schist west of the Housatonic, and still less so in part of the quartzytic mica schist east of the Housatonic; in some of it, the feldspar is partly the species microcline.

Looking at the *constitution of the minerals*, we learn that to the west of the area of Mt. Washington the sediments of which the rock is made were very fine earthy, containing little quartz; that the amount of quartz sand in the sediments increased to the eastward; and that toward the eastern limit of the region, sand was the chief material. The occurrence of arenaceous mica schist overlying, underlying and interlaminating quartzyte beds indicates a small change at intervals in the kinds of depositions such as may have come from changing depths or currents.

All the facts derived from the constitution of the rocks point to a single system of hydrographic conditions and sedimentation; and none suggest the subsequent occurrence of great displacements by long overthrusts any more than those that have been gathered from the stratigraphy. The lithological observations accord with the stratigraphical.

The stratification described is true stratification and not that of a subsequently induced cleavage-structure; for the beds of mica schist, quartzyte and limestone are parallel in interlaminations and interstratifications. Cleavage structure is a common source of lamination in the hydromica (sericite) slates west of Mt. Washington; and hence the true planes of bedding can there be learned only from the contact portions of the limestone and slates; but it is much less common farther east; and the danger of error has been avoided in the observations I have made by taking them at or near the contacts of the different strata or rocks.

The variations geographically from arenaceous to fine earthy beds are just such as are common among the non-crystalline strata farther west, and just such as belong to modern depositions over a region of emerging coasts or flats with an adjoining shelving bottom for a score of miles or so outside. In this part of the Taconic region, the shelving bottom was to the

west of the emerging flats—how far west it extended it is not yet safe to say;—while to the east and south there were, as I have already explained, *isolated* areas of emerged or submerged Archæan rocks, and, adjoining them, in some places, unconformably overlying sandstone (now quartzyte) which is probably of Primordial age.

The gradation in metamorphism does not vary with the amount of flexure in the beds, in this part of the Taconic region, but has depended on some more comprehensive action of this or some other cause.

2. Limestones.

The above conclusion as to increasing grade in metamorphism from west to east is sustained by facts from the limestone of the region that were long since made known by Dewey and Emmons and have been confirmed by all observers. While all is crystalline, the rock west of Mt. Washington is fine-grained and often gray in color; that in Salisbury and Sheffield is a little coarser, ranging from gray to white, the latter much predominating; and in Canaan and to the north, east of the Housatonic, it is mostly a coarse marble and much of it abounds in tremolite, and often also in large crystallizations of white pyroxene. The latter mineral sometimes appears as a rock, called canaanite, in the upper part of the limestone. The tremolite and white pyroxene of the limestone, which are among the results of the metamorphic action that crystallized the limestone, occur to the eastward where the overlying beds are especially arenaceous; and their silica, as I have long since explained, may have been derived from the silica originally in the limestone as an impurity. The limestone is *carbonate* of calcium and magnesium; and tremolite and pyroxene are *silicates* (or rather bisilicates) of calcium and magnesium.*

The gradation in metamorphism from north to south, which the preceding remarks have partly illustrated, I leave without review at this time, as the subject will be better explained after the facts relating to the rest of Berkshire have been presented.

* In a paper in this Journal for 1844 (xlvii, 135) and again in 1846 (II, ii, 88) I point out the fact that the silicates, as well as phosphates, in crystallized limestones may have derived their ingredients from the impurities of the original limestone, though not excluding the possibility of an accession of silica and alkalies sometimes from outside siliceous waters. In my Manual of Geology, edition of 1863 (the first) and later, I make the impurities of a limestone the source through metamorphism, of "its crystalline minerals such as *garnet, idocrase, pyroxene, scapolite, mica, sphene, chondrodite, apatite,* etc." My statements in an article on the limestone of Westchester County in this Journal for 1880 (xx, 28) appear to have led astray Messrs. King and Rowney in "An Old Chapter of the Geological Record," pp. 42, 59. I speak of the tremolite and white pyroxene as a result of the action of hot silicated solutions on a magnesian limestone; but my opinion was then the same as stated in my Geology—that the hot silicate solutions were made within the limestone by the action of heat on the moisture and silica present as impurity.

ART. LVI.—*Notes on the possible age of some of the Mesozoic rocks of the Queen Charlotte Islands and British Columbia;* by J. F. WHITEAVES.

As far back as the year 1869, Mr. W. Gabb expressed the opinion that the Californian rocks, to which he gave the provisional name of the "Shasta Group," were probably the equivalents of the Gault and Neocomian of Europe, and this view was endorsed by Prof. J. D. Whitney. On behalf of the Canadian Survey Mr. J. Richardson visited the Queen Charlotte Islands in 1872, and made a small but interesting collection of fossils from the coal-bearing deposits of Skidegate Inlet. Among the species recognized at this locality were *Ammonites Breweri*, *A. Stoliczkanus* and *Aucella Piochii* of Gabb, of the Shasta group of California, also *Ammonites Timotheanus* Mayor, and *Inoceramus concentricus*, of the European Gault, but associated with these were several new Ammonites which appeared to have rather a Jurassic facies. The conclusion reached on this rather meagre and unsatisfactory evidence was that the rocks bordering Skidegate Inlet could scarcely be much older than the Upper Jurassic or much newer than the Middle Cretaceous.

Four years later Dr. G. M. Dawson obtained a small series of fossils from the bedded volcanic rocks at the Iltasyouco River and Sigutlat Lake, in the Coast Range of British Columbia. Having then no reason to doubt the correctness of Mr. Meek's conclusion that certain rocks in the Black Hills of Dakota were of Jurassic age, the writer of the present article at once assumed that the Iltasyouco and Sigutlat fossiliferous strata were also Jurassic, on account of their holding such fossils as *Gryphæa Nebrascensis*, *Volsella formosa*, *Astarte Packardi*, *Pleuromya subcompressa*, and the like.

The exact age of the "Aucella schists" of Russia, Siberia, etc., has been the subject of much discussion, and European geologists are still at issue on this point. D'Orbigny, in 1846, places them in the "Oxfordien" division of the Jurassic. Trautschold (1864 and 1866) claimed that they are about the age of the Kimmeridge Clay, but later (in 1875) placed them at the extreme summit of the Jurassic system, in the Tithonic Group of Oppel, and this latter view is also maintained by Rudolph Ludwig. Ever since 1867, however, Eichwald has strenuously argued that they are Necomian, and in the only geological section of these rocks which the present writer has seen, the *Aucella* schists are represented as immediately and conformably overlying the Kimmeridge Clay, as the Gault does at Culham in Berkshire (England), a circumstance which many of those who attended the late Prof. Phillips's geology class at

Oxford will remember. Since 1875, deposits holding large numbers of *Aucella Piochii* Gabb (which can scarcely be distinguished from the *A. Mosquensis* of Europe), with a few other fossils, have been discovered by members of the Canadian Survey at several localities on the west coast of British Columbia, on Vancouver Island at Forward Inlet, and in the valley of the Peace River. In a paper "On the Lower Cretaceous rocks of British Columbia" published in the first volume of the Transactions of the Royal Society of Canada, the writer expressed the opinion that those deposits in California and British Columbia, which are characterized by the presence of *Belemnites impressus*, *Ancyloceras percostatus* and more especially by an abundance of *Aucellæ*, represent the lower half of the Shasta Group and are the equivalents of the Upper Neocomian of Europe.

In 1878 Dr. G. M. Dawson, accompanied by his brother, visited the Queen Charlotte Islands and devoted the whole season to an examination of their geological features. From his detailed report upon these islands, which was published in 1879, it appears that the central portion, which includes both shores of Skidegate and Cumshewa Inlets, is occupied by strata which there is now every reason to believe are of Cretaceous age. In descending order the section of these Cretaceous rocks given by Dr. Dawson is as follows. No. 1. The Upper Shales; these have so far yielded only several specimens of *Inoceramus problematicus*, and are therefore supposed to represent the base of the Upper Cretaceous. No. 2. Coarse Conglomerates; these have as yet afforded no fossils that can be identified, but from their position may be assumed to be the equivalents of the Dakota Group. No. 3. The Lower Shales; with coal and iron ore and an abundance of fossils, of which upwards of seventy species have now been described. No. 4. Agglomerates, with a few very indistinct fossils, and No. 5. The Lower Sandstones; these two, from their faunal relations, are believed to be only minor subdivisions of No. 3.

The Lower Shales, or sub-division 3 of Dr. Dawson's report, contain a very rich and varied fauna quite unlike that of any other Cretaceous deposits heretofore recognized in North America. These shales, which the writer has elsewhere ventured to designate "The Queen Charlotte Island Series," are believed to represent the upper part of the Shasta Group of California and the Gault of Europe. Among the fossils which they hold in common with the Shasta Group are *Haploceras Breweri*, *Lytoceras Batesi*, *Hoplites* (?) *Stoliczkanus*, and *Ancyloceras Rémondi*. They have yielded such charcteristic Gault species as *Schloenbachia inflata*, *Haploceras Beudanti*, *planulatum* and *Timotheanum*, *Lytoceras Sacya* and *Thetis major*, var., often in large numbers, also an abundance of *Inoceramus concentricus* and *Actino-*

ceramus sulcatus. As might have been expected, out of the seventy or more species which they contain, a few range upward into the Chico Group of the Upper Cretaceous, and at least three into the lower division of the Shasta Group, which for that reason is supposed to represent the Upper rather than the Lower Neocomian. But, associated with what appear to be purely Cretaceous types, the Lower shales of Skidegate and Cumshewa Inlets hold also at least four or five new species of Ammonites which have recently been described from unusually perfect and well preserved specimens, and which seem to belong to genera, to sections of genera, or to species, which in Europe would be regarded as exclusively Jurassic in their character.

Moreover it is now quite clear that the fauna of the Iltasyouco River and Sigutlat Lake rocks, which the writer at first regarded as of Jurassic age, is essentially the same as that of the Lower shales of Skidegate and Cumshewa inlets. In the coal-bearing strata of the Queen Charlotte Islands and in the volcanic rocks of the Coast Range of British Columbia, associated with characteristic Cretaceous invertebrates, about a dozen species of fossil mollusca have been collected, which the present writer, after long and careful study, has been unable to separate specifically from fossils which Meek and Dr. White have described as Jurassic. A similar apparent mixture of "Jurassic" and Cretaceous fossils occurs in rocks immediately overlying the Alpine Trias, on the Peace River.

Judging exclusively by the invertebrate fossils which they contain and by the stratigraphical position which they are said to occupy, the writer, in a recently published report,* has given at some length his reasons for thinking that the Jurassic age of certain strata in Dakota, Montana, etc., is not yet conclusively proved. The evidence afforded by the vertebrates of these rocks is quite another question and one which has to be considered on its own merits. This aspect of the case has not been discussed at all in the report referred to, for the simple reason that there is not a vestige of a vertebrate, not even a fish scale, in the collection reported on.

In a paper "On the Jurassic Strata of North America," published in the March number of this Journal, Dr. C. A. White objects to the present writer's suggestion that some of the supposed Jurassic rocks of the Western States may possibly be of Middle Cretaceous age, and to the identification of a few fossil mollusca upon which this suggestion was based.

Dr. White's long experience as a paleontologist and his extensive knowledge of the fossil invertebrates of the United

* Mesozoic Fossils, vol. i, Part 3; On the Fossils of the Coal-Bearing Deposits of the Queen Charlotte Islands, collected by Dr. G. M. Dawson in 1878. Montreal, 1884.

States and Territories entitle any views he may express on such subjects to the fullest consideration, and his intimate acquaintance with and ready access to Meek's types from the Black Hills are unquestionably a great advantage. Unfortunately, however, Dr. White could only spare part of a single day for the examination of the large series of Mesozoic and Laramie fossils in the Museum of the Canadian Survey at Ottawa, and only a few minutes each to a study of those species whose identification he objects to.

To the general statements made at the commencement of Dr. White's paper no special exception need be taken here except perhaps on the ground of their want of novelty. They are, in effect, a résumé of that part of Clarence King's volume on the "Systematic Geology" of the United States Exploration of the 40th Parallel which treats of the Jurassic rocks. In that volume, however, Prof. King distinctly states that the Dakota and "Jurassic" rocks are conformable in the Wahsatch Region, also that according to Meek, Hall and Whitfield, the "Jurassic" fossils from the east base of Augusta Mountain have "a Cretaceous and even an Eocene look."

To Dr. White's presentation of the statements and arguments on the other side of the question the writer begs respectfully to demur.

Dr. White says that in the memoir which he criticizes the author thereof "describes and figures *some* fossils" . . . . which are "*reported* to come from certain strata," etc., thereby leading any reader who is ignorant of the facts to suppose that the number of specimens is small and that it is not altogether certain where they came from. Not counting the fossils previously brought back by Mr. Richardson, Dr. G. M. Dawson's collection alone consists of upwards of one thousand specimens, every one of which is labeled not only with its exact locality but also with the precise subdivision of the series in which it was found.

Out of the twelve forms collected by Dr. Dawson which the writer has referred to North American "Jurassic" species, Dr. White objects to the identification of nine, and with regard to these the following remarks are submitted:

1. *Belemnites densus* Meek and Hayden. The specimens described by Mr. Meek under this name are represented as being short and thick or long and slender, as having an apical groove, a median groove or no groove at all. Dr. White says that "Mr. Whiteaves' collection contains only one specimen which he refers to this species," whereas there are two of the short and thick form, seven of the long and slender variety (to which in accordance with a suggestion of Mr. Meek's, the writer gave a local and provisional name) and several large phragmocones.

Moreover this series was directly compared with authentic specimens of *B. densus* from Dakota, received from Mr. Meek, and it was found necessary to mark all the fossils from the two localities as it would otherwise have been impossible to separate them.

2. *Lyosoma Powelli* White. The fact that the writer gave a different generic and specific name to *Vanikoro pulchella* is a sufficient indication that the analogy between it and *L. Powelli* was supposed to be more remote than that which is supposed to obtain in any of the other instances cited.

3. *Pleuromya subcompressa* Meek. The type of this species was figured by Meek in 1873, and since then Dr. White has illustrated three well marked varieties of it. Specimens which agree perfectly with the descriptions and figures of three out of these four forms have been collected at the Queen Charlotte Islands, and two at the Iltasyouco River and Sigutlat Lake.

4. *Astarte Packardi* White. Dr. White admits that, as far as external shape and surface markings are concerned, it is scarcely practicable to separate the British Columbia and Queen Charlotte Island specimens from this species, but says that the hinge and interior markings of the type of *A. Packardi* are unknown. In this genus, as every experienced malacologist is aware, the interior of the valves affords a certain indication of its generic relations but is of very little assistance in the determination of species.

5. *Grammatodon inornatus* Meek and Hayden. Dr. White says that "Mr. Whiteaves' specimens do not show the hinge." This is quite correct as regards the fossils from the Queen Charlotte Islands, but one of the specimens from the Iltasyouco River shows the impression of two short posterior lateral teeth parallel to the hinge line, just as in Meek's figure of *G. inornatus* on plate 3, fig. 9b, of the "Palæontology of the Upper Missouri."

6. *Modiola* (*Volsella*) *subimbricata* Meek. The specimens from the Queen Charlotte Islands referred to this species, though somewhat distorted, are nearly perfect single valves. Dr. White does not comment at all on the real or supposed identification of a Sigutlat Lake specimen with the *Modiola* (or *Volsella*) *formosa* of Meek and Hayden, one of the strongest points in the writer's view of the case. At the Iltasyouco River, too, specimens have been found which are very difficult to distinguish from *Modiola platynota* White.

7. *Pteria* (*Oxytoma*) *mucronata* Meek and Hayden. Of this the writer is said to have only one imperfect valve and Dr. White adds "that the most that can be said of it is that it apparently indicates a form which is much like the *P.* (*O.*) *mucronata* of Meek and Hayden." In answer to this statement

it may be observed that while only one imperfect valve was collected in Alliford Bay, yet several perfect specimens of both valves were obtained at Maud Island. In the writer's judgment the least that can be said of the whole of the specimens collected by Dr. Dawson is that they agree perfectly with Meek's description and figure of *Pteria* or *Oxytoma mucronata*.

8. *Camptonectes extenuatus* Meek and Hayden. The lower valve of a small Pecten from Maud Island which was somewhat doubtfully identified with this species is quite perfect in marginal outline, has most of the test preserved, with its characteristic sculpture, and shows the shape of both ears. An upper valve, from the Iltasyouco River, corresponds remarkably well with Meek's figure of the type of *C. extenuatus*.

9. *Gryphaea Nebrascensis* Meek and Hayden. Dr. White says that the specimens, regarded by the writer as probably identical with this species, are more like *Gryphaea navia* Conrad. The irregular, radiating striæ on the umbonal region which are characteristic of *G. Nebrascensis*, and which are well seen on specimens from the Queen Charlotte Islands and from the Iltasyouco River, are altogether absent in *G. navia*, which latter shell has also a narrowly subtrigonal outline with angulated beaks and a sharp umbonal ridge, a combination of characters which is not seen in *G. Nebrascensis*, nor on any of the specimens collected by Dr. G. M. Dawson.

Art. LVII.—*Crystallized Tiemannite and Metacinnabarite;* by Samuel L. Penfield.

1. Tiemannite.

In October last, Professor J. E. Clayton, president of the Salt Lake Mining Institute, sent to Prof. G. J. Brush a few specimens containing crystals of a selenide of mercury which were suitable both for analysis and measurement. The specimens were from Marysvale, Southern Utah, the same locality which afforded the sulpho-selenide of mercury, onofrite,* described by Professor Brush. A description of the occurrence of the mineral, as stated by Prof. Clayton, is given at the end of this article, and I take great pleasure in here expressing to him my thanks for calling our attention to these most interesting crystals.

The crystals are black, with high metallic lustre and black streak; hardness about 3; specific gravity taken twice on a chemical balance 8·188–8·187; fracture conchoidal; very brittle and with no apparent cleavage.

* This Journal, III, xxi, 312.

A analysis was made by decomposing the mineral in a current of chlorine gas, precipitating the mercury as sub-chloride by means of phosphorous acid and the selenium with sulphurous anhydride. The results are given below with the determinations of small amounts of sulphur, cadmium and insoluble residue.

		Ratio.		
Se	29·19	·369	·381	1·00
S	·37	·012		
Hg	69·84	·349		
Cd	·34	·003	·352	0·92
Insol.	·06			
	99·80			

The ratio of the selenium plus sulphur to the metals is 1 : 0·93 or nearly 1:: 1, that required by a normal selenide, and as the impurities are present only in very small quantities the mineral may be regarded as a simple selenide of mercury. The analysis agrees more closely with the theoretical requirements than any previously published, which may be in consequence of the greater purity of the crystallized material.

The crystals measure up to 3mm in diameter. They are isometric, tetrahedral, and the habit of the few at my disposal is quite various. The plus and minus tetrahedrons are usually about equally developed and vary in luster; the cubic faces are also prominent and are at times striated diagonally parallel to

Fig. 1.

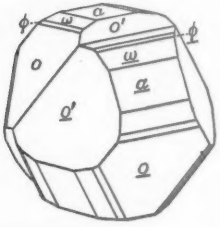
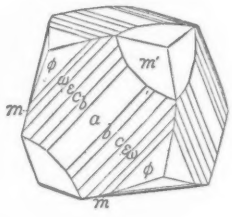


Fig. 2.



their intersection with the dullest tetrahedron and most developed $\frac{1}{2}(m\text{-}m)$ forms. Twins with o as the twinning-plane are common. Taking the forms of the most developed $\frac{1}{2}(m\text{-}m)$ as positive, the observed forms are as follows: o (111, +1), usually dull, $o'(\bar{1}11, -1)$ lustrous, $a(001, i\text{-}i)$, $w(511, +5\text{-}5)$ and $\varphi(733, +\frac{7}{3}\text{-}\frac{7}{3})$. The above forms were all observed on one twin crystal, fig. 1, the latter φ, as a very small face but giving distinct reflections. The faces in both halves of the twin crystal figured are lettered alike except that those in twin position are underscored. Twins on the specimens in my possession are more common than single crystals, some of them showing simply both tetrahedrons and cube.

The measured angles are the following, the mean of closely agreeing results being given:

		Observed.	Calculated.
$o \wedge o'$, 111 $\wedge$ $\bar{1}11$	=	70° 31′	70°32′
$a \wedge o'$, 001 $\wedge$ $\bar{1}11$		54° 45′	54°44′
$a \wedge \omega$, 001 $\wedge$ 115		15° 45′ 15° 50′	15°48′
$a \wedge \phi$, 001 $\wedge$ 337		31° 10′	31°13′

A number of crystals have the habit shown in fig. 2; only one was lustrous enough to admit of measurement. The zone *a*, *b*, *c*, etc., was very much striated and distorted through oscillatory combination, but by turning the crystal so as to catch the light reflected from it, it could be readily seen to consist of several distinct forms. On the reflecting goniometer the signal was reflected from the faces in almost an unbroken band; a few of the most prominent reflections, however, were recorded and are given below. The reflection from the faces of a lamplight placed at a distance across a large room was resorted to, all the faces of like inclination reflecting together and yielding a sort of "schimmer Messung;" the results of which although not very exact being sufficiently so to fix the symbols of the different forms. The measurements taken on both sides of, and measured from, the cubic face *a*, are given below.

	b	*c*	*ε*	*ω*	*m*	*φ*	
Direct reflection	6° 11′	9° 17′	12° 30′				right.
Schimmer	6° 17′	9° 24′	12° 42′	17° 17′			right.
	6° 25′	9° 49′	12° 58′	17° 16′			right.
Direct reflection	6° 12′						left.
Schimmer	6° 7′	9° 17′	12° 20′	16° 26′	25° 7′	31° 23′	left.
	5° 50′	9° 2′	11° 47′	16° 20′	25°		left.
Mean	6° 10′	9° 22	12° 27′	16° 47′	25° 3′	31° 23′	

Calculated for the following forms.

16° 13′ 9° 27′ 12° 16′ 15° 48′ 25° 14′

$(13\cdot1\cdot1, +13\text{-}13), \left(17\cdot2\cdot2, +\frac{17}{2}-\frac{17}{2}\right), \left(13\cdot2.2, +\frac{13}{2}-\frac{13}{2}\right), (511, +5-5), (311, +3-3),$

31° 13′

$(733, +\frac{7}{3}-\frac{7}{3}).$

The reflections from ω, *m* and φ were very faint, that from φ being the last trace of reflected light which could be seen on turning the crystal. The measurements agree quite well among themselves, considering the method used, and warrant my taking the above symbols according to which fig. 2 is drawn. The form $\omega(511, +5\text{-}5)$ shows the greatest variation, but, as it is a prominent form on the simpler and more perfect crystals, it seems better to regard the variation as due to error in measurement than to take the less probable symbol $(922, +\frac{9}{2}-\frac{9}{2})$ with calculated value 17° 27′. The only other form $m'(\bar{3}11, -3\text{-}3)$ was quite large and very strongly striated parallel to its combi-

nation edge with the cube. The faces gave no reflection but were measured by covering them with glass plates and then measuring on the cube. This was repeated twice giving 24° 49′, 25° 21′, calculated 25° 14′.

In appearance the crystals resemble very closely those of sphalerite while the forms which are common to both are $a(100, i\text{-}i)$, $o(111, +1)$, $o'(1\bar{1}1, -1)$, $\omega(511, +5\text{-}5)$ and $m(311, +3\text{-}3)$.

2. Metacinnabarite.

The specimens of this mineral at my disposal, from the Reddington Mine, Lake Co., California, were from the collections of Prof. G. J. Brush and Mr. C. S. Bement. The mineral is intimately associated with crystallized cinnabar and marcasite. Mr. G. E. Moore first described this species* as an amorphous black sulphide of mercury, distinct in its physical properties from cinnabar. He states that specimens which he examined from the collection of Prof. Brush showed small crystals "whose habit is almost cubical" and "betray in their frequent re-entrant angles a strong tendency to the formation of twins." The specimens at my disposal show crystals up to 4^{mm} in diameter, they are apparently isometric, tetrahedral, but the faces are such that they do not admit of accurate measurement. The habit of the crystals is mostly octahedral with the alternate faces of the plus and minus tetrahedron varying in luster. The faces are usually dull black and rough, giving no reflection, or curved. Measurements on the tetrahedral face could not be obtained. The forms which I have been able to identify are the following, while the measured angles are given in the table below, $(322, \frac{3}{2}\text{-}\frac{3}{2})$, common, occurring sometimes alone in one set of secants, at times truncating the edges of an apparent octahedron (plus and minus tetrahedron). One specimen contained small crystals of the form (211, 2-2), in combination with small and rough faces of the tetrahedron of the opposite order. On one crystal the faces in one set of secants were quite bright and contained markings and small faces indicating a $(hkl, m-n)$ form; the measurement of the two kinds of edges in the secant, as far as I was able to obtain them, gave for the values of m and n respectively 1·849 and 1·233, perhaps $(975, \frac{9}{5}\text{-}\frac{9}{7})$, but as the reflections were not very distinct and could not be repeated on a second crystal it seems useless to assume a symbol for this form. The cubic faces occur very seldom on the specimens examined by me. Twins parallel to an octahedral plane are very common, often repeated as in sphalerite.

* This Journal, III, iii, 36.

The measured angles are as follows:

$322 \wedge 3\bar{2}\bar{2}$	86° 34′	
	86° 52′	86° 38′
	87° 17′	
$211 \wedge 112$	36° 54′	
	33° 24′	33° 34′
	33° 15′	

Although the crystals are poorly adapted for measurement their habit is characteristically isometric tetrahedral, and the measurements as far as made agree with isometric forms. After seeing the specimens at my disposal it seems strange that the name "amorphous sulphide of mercury" should have been so long attached to this mineral.

After carefully cleaning the crystals used for measurement and freeing them as far as possible from attached cinnabar, the specific gravity was taken with great care on a chemical balance, with 7·81 as the result. As the three crystals weighed together only ·1684 grams the result can not be regarded as very accurate, but I thought it would serve to compare with the specific gravity of the amorphous sulphide given by Mr. Moore as from 7·701–7·748.

The crystallographic results taken in connection with those on tiemannite, with which the mineral stands in close chemical relation, leaves little doubt as to the isomorphism of the two minerals, and the isometric character of metacinnabarite, while the intermediate chemical compounds to which the name onofrite has been applied and which are not known in crystals stand intermediate between the two in physical relations.

Relation between the selenides and sulphides of mercury.—As the density which I found for the crystals of tiemannite, viz: 8·19, was greater than that given by other authors (this usually being 7·1–7·4, Blum giving 7·8–7·88), I thought it would be best to take the density of the material from Clausthal, which was all that was at my disposal. The material was quite impure, but after taking the density the volatile selenide was driven off, the density of the residue taken and that of the pure material calculated. I also took the density of three specimens of onofrite from Utah; in these cases, however, the residue was smaller and was regarded as having a density of 2·7. Undoubtedly it was heavier and the true density of the mineral would be correspondingly lower.

All the densities which have been found are the following:

I. Tiemannite, crystallized, from Utah	8·19
II. Tiemannite, Clausthal, after deducting 16 per cent of impurities	8·473
III. Tiemannite, Clausthal, after deducting 39 per cent of impurities	8·305
IV. Onofrite, Utah, after deducting 1·3 per cent of impurities	7·98
V. Onofrite, Utah, after deducting 1·6 per cent of impurities	8·09
VI. Onofrite, Utah, after deducting 2·9 per cent of impurities	8·04
VII. Metacinnabarite, California, crystallized	7·81
VIII. Metacinnabarite, California, amorphous, determined by Moore	7·70 7·75

It will be seen that onofrite stands, as it should, intermediate between the selenide and sulphide. No. IV of the above list was analyzed by Mr. Wm. J. Comstock* and consists of 13·7 per cent HgSe and 86·3 per cent HgS. Calculating the density of an isomorphous mixture in the above proportions taking the density of HgSe=8·2 that of HgS=7·8 we obtain 7·85 as against 7·98 observed. Onofrite is therefore physically intermediate between tiemannite and metacinnabarite, and represents an isomorphous mixture of these two isometric molecules. It is strange that the conclusions arrived at by Prof. Brush in the article already referred to, should have been the same, although he based his conclusions on earlier and incorrect determinations of the density of tiemannite.

As to the position which these minerals should occupy in a natural grouping, it seems that they would naturally come into the sphalerite group with which they have many things in common, being simple selenides or sulphides, with mercury replaced in part by zinc or cadmium, crystallizing in the isometric system, tetrahedral, and with strong tendency to twinning parallel to the octahedron.

In closing I take pleasure in expressing my thanks to Prof. Brush and Mr. C. S. Bement for the material which they provided for carrying on this investigation.

Note as to the occurrence of Tiemannite; by Prof. J. E. CLAYTON. Communicated by letter to Prof. Brush, dated Salt Lake City, October 6th, 1884.

The mine is situated above five miles S.W. of Marysvale, two hundred miles south of Salt Lake City. It is on the east face of a mountain slope and near to a profound fault extending north and south. To the east are eruptive rocks including porphyry and trachyte. Underlying the ore beds to the west is quartzyte of unknown thickness, over this about four hundred feet of gray limestone and in the contact between these the Deertrail vein is situated, carrying gold, silver, lead and a little copper. In the upper portions of the limestone the selenide of mercury is found in a bed of shaly limestone fifteen to twenty feet thick. The vein has been traced north and south about one hundred feet along the outcrop and dips into the mountain at an angle of about 15° below the horizon. The ore occurs in masses intermixed with the shaly limestone, crystals being very rare. The accompanying minerals are barite, oxide of manganese, quartz and calcite. The ore bed is overlaid by a yellowish, sandy, lime-shale carrying Subcarboniferous fossils.

Mineralogical Laboratory Sheffield Scientific School, March 28th, 1885.

* This Journal, III, xxi, 312.

Art. LVIII.—*On the Gahnite of Rowe, Massachusetts;* by Arnold Guyot Dana.

In some car-loads of pyrite brought to New Haven, Connecticut, from the mines of J. M. Davis & Co., in the town of Rowe, Massachusetts, eight miles east of the Hoosac tunnel, I found some fragments of the mineral gahnite. On visiting the locality I learned that the gahnite occurred on the outer portions of a "vein" or "lenticular mass" of pyrite, of exceptional purity, varying from seven to twenty feet in thickness. The including rock is gneiss and schist. The mine had, at the time of my first visit, reached a depth of 200 feet. The waste heaps afforded a large amount of material and some good specimens, though the hardness of the enclosing rock made it difficult to obtain the crystals unbroken. Part of them were entirely embedded in the pyrite and part seemed to have once lined cavities, most of which had since been filled in by quartz and the rest by chalcopyrite.

The crystals in the quartz were greenish in color and sometimes had a slightly greasy lustre, while those in the pyrite were almost black, but green by transmitted light, and had a high vitreous lustre. These latter, though apparently the most pure, were so filled with minute particles of pyrite that for analysis it was necessary for the most part to use those in the quartz.

The largest crystals had a diameter of three-quarters of an inch, but the majority were much smaller. Their habit was octahedral, with the faces usually built up terrace-like from the alternations of the octahedron with the dodecahedron. Simple dodecahedrons were rare. No other planes were observed, though many crystals were examined. Good examples of the spinel twin were occasionally met with.

The specific gravity taken on a piece of exceptional purity weighing nearly two grams was 4·53.

An analysis of the gahnite, made because of the refractory nature of the substance on half a gram, gave:

	I.	II.	Mean.
Al_2O_3	54·61	55·04	54·83
Fe_2O_3	3·22	2·79	3·00
FeO	3·25	3·49	3·37
MnO	*tr.*	*tr.*	*tr.*
MgO	2·01	1·86	1·93
ZnO	36·91	36·93	36·92
SiO_2 and insoluble residue	·57	·48	·53
	100·57	100·59	100·58

The mineral was decomposed by repeated fusion with $K_2S_2O_7$. The insoluble residue having been filtered off, the zinc was thrown down as sulphide by H_2S in an HCl solution—according to the method elaborated by Mr. Osborne of this laboratory*—then dissolved and re-precipitated as carbonate. The ignited ZnO was examined for iron and the small amount found taken into account. The alumina and iron were twice precipitated as hydroxides with NH_4OH and weighed together. The iron was determined by titration with permanganate of potash, and the alumina obtained by difference. The amount of iron obtained was divided between the protoxide and sesquioxide in such proportion that the oxygen ratio should be as the formula demanded. The magnesium was weighed as pyrophosphate.

Besides the pyrite, which is seldom found in crystals of any size, the chalcopyrite and the quartz, the minerals associated more or less intimately with the gahnite are: thin plates of titanic iron, sometimes an inch across; steel gray rutile, occasionally in good crystals; apatite in small light green crystals; sphalerite; garnet; calcite; a triclinic feldspar in greenish crystals, and epidote.

The epidote occurs in curving, thick columnar forms and mostly in the pyrite. It is nearly opaque and of a greenish gray color passing into ash gray.

An analysis showed that it had the following composition:

	I.	II.	Mean.
SiO_2	38·18	38·23	38·20
Al_2O_3	24·57	24·66	24·62
Fe_2O_3	12·16	12·24	12·20
MnO (two separate portions)	·57	·57	·57
MgO	·12	·14	·13
CaO	21·64	21·54	21·59
Alkalies (one portion)	·37	·37	·37
H_2O	2·15	2·17	2·16
Insoluble residue	·35	·34	·35
	100·11	100·26	100·19

Ca : R : Si = 409 : 935 : 1·272 or nearly 4 : 9 : 12

In this connection it may be interesting to add that during a recent visit to Franklin Furnace, New Jersey, I found the gahnite imbedded in magnetite from the "Trotter" mine. One crystal $\frac{6}{10}$ of an inch in diameter had the planes O, 1, *i* and 3-3 well developed.

Laboratory of the Sheffield Scientific School, April, 1885.

* Am. Chem. Journ., vi, No. 3.

ART. LIX—*The Genealogy and the Age of the species in the Southern Old-tertiary*; by OTTO MEYER, PH.D.

HAVING for some time been engaged in the study of the Old-tertiary formation of the Southern States, especially of Alabama and Mississippi I have reached the following results:

1. This formation contains so many forms that have not hitherto been made known, that the existing lists, their other faults not considered, can be said to give only a poor picture of this fauna.

2. For the three main localities, Vicksburg, Jackson and Claiborne, which are succeeding beds, a genealogy (see the table beyond) can be made out for many species. They can be traced through two beds or all three of them, either remaining unaltered, or varying somewhat, or varying in such a degree, that different specific names must be used. In other words: many described and undescribed species are most probably connected by descent.

3. Since the discovery of these beds it has been generally accepted, that the "Claibornian" is the oldest and that their succession is as follows: Claiborne (Middle Eocene), Jackson (Upper Eocene), Vicksburg (Oligocene); the existing maps are colored accordingly. This has been done without sufficient reasons and it is even very probable that the succession is just the contrary—Vicksburg the oldest and Claiborne the most recent formation.

As for the new species I hope to be able to describe them soon. I am obliged to name and describe a part of them in the following pages without figures. But most of them are defined, though briefly, yet exactly, by giving the differences from allied known species. I think that a paleontologist collecting at the same locality will be able to recognize them, and this is more than can be said for many species described and figured from this Tertiary.

PART I.

The Genealogical Relations of the Species.

If we have three formations, one above the other, not separated by a geological gap or by long geological times, but apparently deposited during a gradual rising of the coast, we may expect the following. Many of the species will remain unchanged or vary to some extent, others will vary very much. If variations of a species disagree more and more they may

become different species. Some species may become extinct or emigrate, others may immigrate. These last points can be determined only by a complete knowledge of the respective faunas. But many of the variations can be recognized with the assistance even of a part of them, such as is represented by our collections. All the conclusions in this essay are based upon material in my possession, collected by me in the localities mentioned. I have used the existing descriptions and figures only for determining the specimens found in the same place, and have not drawn a conclusion nor made a suggestion (marked by [ ]), except by direct comparison of specimens. Thus the table shows only the relations between the materials in my present collection, and future collecting may add many new points.

In tracing out relationships between different species the following considerations were guiding.

Species, which disagree above a certain moderate extent in their embryonic parts, cannot be nearly allied, however similar they may appear.

The differences between related species must be generally of a more quantitative than qualitative nature.

While some of the qualities may differ, perhaps even considerably, most of them must be expected to remain unchanged.

If two related species differ in certain points, it is to be expected that they will vary somewhat in the same points in at least one of the localities.

Very small peculiarities in teeth, striæ, pits, etc., usually not mentioned in descriptions, are sometimes very characteristic of a species and remain constant, when other qualities vary. These little things sometimes give good indications of relationships.

It must not be forgotten that not the animals, but only the shells can be compared, and what may be considered a slight difference in the shell may represent a considerable difference in the animals; or the reverse may be the case. What I deem as too slight a difference to make varietal or specific distinctions, may be thought by other authors of sufficient importance to render these distinctions necessary; or, on the contrary, others may find my distinctions exaggerated. Moreover I may have made, notwithstanding all care, in one case or another entirely wrong relationships. All these considerations may influence every single detail represented in the following table, but in general the relationships here claimed between the three faunas are beyond doubt. From a review of the geological and paleontological evidences *I cannot explain these relations other than by derivation.*

When Conrad described the Vicksburg and Jackson species,

he identified very few of them with Claiborne fossils, but founded new species on very small differences. He had often to say "related to . . . from Claiborne." Afterwards he was of the opinion, that the three beds had no species at all in common and gave new names to those which he formerly considered identical. It would be very difficult to defend this hypothesis even if no other species occurred in Jackson than those which he described, but with a better knowledge of the rich Jackson fauna it is impossible. The synonyms in parentheses in the table are the names used by Conrad. The table will explain itself in general and in the following pages only such explanations are made as are necessary. The references to the literature of most of the species can be found in the American Journal of Conchology, 1865, pp. 1–35. The numbers refer to those in the table.

3. From Jackson I have two specimens, which are distinguished from *Discoflustrellaria Bouéi* Lea sp. in being flat and having longer cells. I call them *Discoflustrellaria Jacksonensis.* They may be a variety or different species, but are to be related to the Claiborne form.*

7. *Pecten Lyelli* Lea occurs also in Jackson. I would here call attention to a characteristic mark that Lea does not mention,—four or three teeth on the margin below the large wing.

8. *Pecten Deshaysi* Lea is very similar to *Pecten nuperus* C. To this latter form I relate that species in Vicksburg which Conrad omits from his lists, though it is the most abundaut one in that locality. In Hilgard's Geology of Mississippi it is called *Pecten Poulsoni.* I have no typical *Pecten Poulsoni* Morton from St. Stephens, to ascertain whether this name is right or not. At first sight one may be surprised, that I relate these two species, one of which is moderately inflated, while in the Vicksburg species one valve is very ventricose and the other nearly flat. But in this regard *P. Poulsoni* varies considerably. One may pick out valves which are entirely flat, and others which have a relatively large inflation, and the agreement in the ornamentation was of decisive value for me.

Pecten Lyelli and *Pecten Deshaysi* are probably only two different valves of one species.

14. In Jackson occurs a species, *Limopsis radiatus,* n. sp., agreeing with *Lim. obliquus* Lea sp. from Claiborne, but somewhat larger and having radiating ribs. The latter difference is so striking, that I should not have related the two species to each other, except perhaps by a [ ], had I not a specimen of *L. obliquus,* which shows the same ribs. Though they are less distinct they are formed in the same manner as in the Jackson form by nodules on the concentric striæ.

16. The two Claiborne species, *Leda plicata* Lea sp. and *Leda*

* The danger of misrepresenting Mr. Meyer, in attempting to remove his German idioms, leads us to leave them as written.—EDS.

media Lea sp. have the following differences. *L. plicata* is compressed, very inaequilateral; the concentric ribs continue over its anterior portion and on this portion there is a radiating furrow. *L. media* is more inflated, the beaks are medial, the concentric ribs look as if erased on the anterior portion and there is no furrow. In Jackson a species is not rare which may be called *Leda mater.* I have also a specimen of it from Claiborne. This species has the inequilateral form of *L. plicata;* the position of the beak however is not quite constant and is sometimes a little more medial. It is inflated like *L. media,* but some specimens are more compressed. The folds on the surface continue generally over the anterior portion, but become less distinct there and sometimes even vanish. A slight furrowing of the anterior portion may be noticed in most of the specimens, but not in all. In short, *Leda mater* in Jackson stands between *L. plicata* and *L. media;* it varies in certain features, and the same features constitute in a developed form the differences between the two species in Claiborne. From these facts the conclusion might be deduced, that the two species are also derived from *L. mater.*

17 and 18. *Astarte sulcata* Lea occurs in Jackson with more numerous concentric ribs and seems to be generally stouter than in Claiborne; this may justify a varietal name var. *Jacksonensis.* It is very singular that the same differences exist between *Astarte Nicklini* Lea and *Astarte parilis* C.?,* so that we find two similarly looking species of one locality altered in the same manner in the other place.

19. *Astarte* (Micromeris) *parva* Lea occurs also in Vicksburg in a form which is broader and less ribbed, var. *Vicksburgensis.* A specimen from Jackson is more similar to the Claiborne form.

22. In Jackson occurs *Venericardia diversidentata,* n. sp., similar to *Vener. rotunda* Lea, but with a larger beak, and the tooth of the left valve horizontal, while in the Claiborne species it rises obliquely. Though one of the Claiborne specimens has also a large beak, the differences appear to me of such importance as to require a new specific name. The relation to *Vener. rotunda* is so obvious, that for instance in Hilgard's Geology of Mississippi it is enumerated under this name. In the young specimens of the Claiborne species the tooth has nearly, or perhaps entirely, the same form as in the Jackson species.

23. *Venericardia parva* Lea occurs in Jackson in a smaller form with straighter lateral margins. These two qualities are not constant in Claiborne, and the distinction is properly made by a varietal name, var. *Jacksonensis.*

24. A specimen from Claiborne resembles *Venericardia parva* Lea, but is very distinct by being still smaller, very much inflated, having a much larger beak and less nodulous ribs. It may be called *Venericardia inflatior.* The same form is also rare in Jackson in a variety with straighter lateral margins, var. *Jacksonensis.*

* There exists no description of this species and from the poor figure I can only guess this determination.

27. I have *Lucina Mississippiensis* C. only from Jackson and this is the only exception to the rule, to compare only specimens. But this Lucina is very characteristic and agrees exactly with the figure and description of the Vicksburg species.

30. A species of Lucina is common in Jackson, and not very rare in Vicksburg, which is suborbicular and rather flat. Lateral teeth are obsolete; beak medial, acute and turned anteriorly. Posterior margin is truncated and posterior extremity subcanaliculated. It is covered with concentric striæ, less numerous on the posterior side, which have a tendency to become prominent on the carina and near the margins. Margin entire. This species is not named as it may perhaps be identical with Conrad's *Lucina Claibornensis*,* although Conrad says in his description "inequilateral." He describes this species from Claiborne, but from a "group at the base of Claiborne Bluff, belonging to an older division of the Eocene than the Claiborne group above."

31. *Cardium Nicolleti* C., from Jackson, and *Cardium diversum* C. from Vicksburg have only quantitative differences in the ornamentation.

33. The genus Cytherea seems here to vary very much. It is not only difficult to find out relations between the species, but even to separate the species, especially in Claiborne, when the material of the lowest and highest Claibornian (see part II) is mixed. In Jackson the genus is rarest and my material from this locality poor. One perfect specimen from Jackson, *Cytherea Jacksonensis*, n. sp., agrees with *Cytherea Hydi* Lea, but has a narrower hinge. The size of the hinge in Claiborne, however, is not quite constant.

35. A rather common Tellina in Jackson is a larger and stouter variety, var. *robusta*, of a Vicksburg species, which I determined as *Tellina Vicksburgensis* C. A young Jackson specimen has the same form as one of the stouter Vicksburg specimens.

36. In Jackson occur fragments, which seem to differ merely in size from *Periploma Claibornensis* Lea sp., which species also is known only in these fragments. The Jackson form may be called var. *parva*.

37. In Jackson occurs a species of Mactra, which is almost equilateral, but otherwise does not differ from *Mactra pygmaea* Lea, from Claiborne. As the forms vary in both localities they are most probably to be related. The Jackson specimens are very similar or identical with a species in Vicksburg, which is perhaps what Conrad called *Mactra funerata*.

38. A new species, *Mactra inornata*, occurs in Jackson. It is small, somewhat flattened, inequilateral and has a rather solid shell. The margin is entire, the lower margin rather straight. Concentric striæ on the extremities are seldom noticeable, because the surface is mostly water-worn. In a specimen from Claiborne I cannot find any difference. A specimen from Vicksburg is relatively higher.

* Am. Jour. Conch., 1865, p. 146.

39. A Corbula in Jackson differs from *Corbula gibbosa* Lea in having less distinct concentric ribs and a much smaller beak. The last difference is important enough to justify a new name *Corbula Willistoni*,* but otherwise the details are alike.

40. *Corbula bicarinata* C. from Jackson differs from *C. Murchisoni* Lea in having the concentric ribs somewhat more numerous and the umbonial carina less distinct, but this variation is slight.

41. *Corbula densata* C. from Jackson has indeed, as Conrad says, a shorter form and a more rounded base than *C. Alabamiensis* Lea, but there are quite a number of specimens of almost the same appearance in Claiborne, which I tried in vain to separate specifically from the elongated forms. So the stout specimens can be considered only a variety.

43. From Vicksburg and Claiborne I have a Dentalium, which agrees with my specimens of *Dent. microstria* Heilpr.† from Wood's Bluff. One of the Claiborne specimens has the posterior aperture complete, showing an emargination and opposite to it a fissure. Although Heilprin in his description says "posterior aperture entire, there being no fissure," I have little doubt that it is the same species and that he described an incomplete aperture. The species is too rare and occurs too fragmentarily to enable me to give a sure representation of its variation.

44. A small, smooth, even somewhat polished Dentalium, occurring in Vicksburg and Jackson, is distinguished from all other American species by being compressed, the section showing about the form of an egg. It resembles remarkably that species from the German Oligocene, which I described as *Dentalium compressum*.‡ To indicate this relation it may be called *Dentalium subcompressum*.

45. In Claiborne occurs a Dentalium, which has not been described, though fragments of it are not rare. The shell is solid, smooth without any ribs; section circular. The posterior aperture is formed very characteristically. The margin is notched twice; the notches are opposite, deep and almost of the same size as the remaining two opposite prominences of the margin. From within, a little tube rises. This species may be called *Dentalium Leai* in honor of I. Lea, whose "Contributions to Geology" I consider as the best part of the American Tertiary literature. In Jackson occurs a species, fragments of which cannot be distinguished from the Claiborne form. The posterior aperture however, although showing also the little tube, has only one of the notches, which moreover is less deep. It may be called *Dentalium Danai*. As the other notch is at least indicated by a slight emargination, the species are to be related to each other.

46. In Vicksburg and Jackson occur quite a number of species of Cadulus. One of them in Jackson, *Cadulus Jacksonensis*, n. sp., is the largest one. The inflation is near the anterior

* In honor of my friend Dr. S. W. Williston, U. S. Geological Survey.

† Proc. Ac. Nat. Sc. Philad., 1880, p. 375.

‡ Jahresb. d. Senckenb. Naturf. Gesellsch., Frankfurt a. M., 1882–3, p. 258.

aperture. Aperture and section are not circular but ovate, the species, however, is not as much depressed as *Cadulus depressus* Meyer* from Claiborne. The most characteristic is the posterior aperture. By four notches or fissures this end is divided into four turret-like appendages, similar to what Lea describes in his *Dentalium turritum*. Of these four prominences only the opposite ones are alike; two are small and simple, the other two broad and slightly emarginate in the middle. The largest species in Vicksburg has apparently the same form and almost the same aperture, but in the emargination of the two large appendages there seems to be a difference, and the specimens are smaller than in Jackson. It may be considered either a variety or a different species, and may be called *Cadulus Vicksburgensis*.

What Lea described as *Dentalium turritum* is apparently a fragment of a large Cadulus with well preserved posterior aperture, and not a fragment of a Dentalium with "accidental" aperture, as Conrad once suggested. As Lea, who observed very exactly, writes "aperture round" it is probably not identical with the strongly compressed *Cad. compressus* Meyer. I found of the latter species, unfortunately, no well preserved posterior termination, and not having seen Lea's type-specimen I cannot have a decided opinion about the relation of the Jackson to the Claiborne species.

47. From Claiborne I have two species of Teinostoma. Both are small, the umbilical region is completely covered by a callus, which has a tendency to spread over the whole shell. Where it does not cover the shell, revolving lines are to be noticed. The two species differ very much, as one of them, *Teinostoma subrotunda*, n. sp., has the last whorl with an almost imperceptible angle, while the other, *Teinostoma angularis*, n. sp., is extremely carinated. In Jackson occurs *Teinostoma Verrilli*, n. sp., which differs from *Tein. subrotunda* in having a more distinct angle and showing no revolving lines. In a young specimen from Vicksburg I find no difference from the young Jackson form.

50. *Solarium Henrici* Lea, from Claiborne agrees with *Solarium bellastriatum* C. from Jackson, but in the latter species there are two revolving, impressed lines directly above the suture very distinctly developed, while in the Claiborne form they are only indicated or quite obsolete. At the base of *S. Henrici* we find one distinct line around the umbilicus and an indistinct one along the margin; at the base of the Jackson species the umbilical line is very much impressed, along the margin there are two distinct lines and one more line on the middle of the whorl. Some of the Jackson specimens show indistinct traces of more longitudinal lines; these other revolving lines are fully developed in the Vicksburg species, *Solarium triliratum* C.

This relation between the three forms is one of the best illustrations of evolution, which can here be brought forth. The three Solaria appear different enough to justify specific names. On

* Proc. Ac. Nat. Sc. Philad., 1884, p. 111.

the other hand the resemblance is too evident to be overlooked. The Jackson form may be said to stand exactly in the middle and without this connecting link the difference between the Vicksburg and the Claiborne species might appear too great to indicate their derivation.

51. *Turritella carinata* Lea varies to such an extent in Claiborne, that the specimens there disagree at least as much from each other as they are different from the forms in Jackson and Vicksburg. For this reason I prefer not to use varietal names for these two localities.

52. *Turritella lineata* Lea, from Claiborne, increases in width much more rapidly than *T. alveata* C. from Jackson, where the first whorls are flat and only the older whorls become rounded. But these species are perhaps to be related to each other.

56. The Claiborne species *Natica parva* Lea reaches in Jackson a considerable size. The umbilicus seems to be a little smaller and also the broad emargination of the inner lip near the umbilicus seems to be slighter, but I will not propose a special varietal name. A characteristic of *Natica parva* is that the upper part of the whorls is broadly canaliculated. This quality is obsolete in a new species from Vicksburg, *Natica decipiens.* As form and umbilicus, however, are alike, and smaller markings agree, for instance a callous prominence on the posterior part of the mouth, I relate them to each other.

59. Besides *Eulima aciculata* Lea sp., there is in Claiborne a very rare species of Eulima, as highly polished and of about the same form, which is characterized by an indistinct suture. The same species is less rare in Jackson and Vicksburg, at least I cannot detect specific differences. *Eulima exilis* Gabb, from Texas, which I do not have, seems to have the same indistinct suture, and is perhaps identical.

61. In Jackson occurs a species nearly allied to *Distortrix septemdentata* Gabb from Texas. It differs in having the canal somewhat reflected, being more callous on the inner lip, having more prominent varices and more distinct transverse ribs. It may be called *Distortrix Jacksonensis.* This species is probably to be related to *Distortrix crassidens* C. from Vicksburg.

65. In Jackson and Vicksburg occurs a species, *Fusus Boettgeri,** n. sp., closely allied to *Fusus subtenuis* Heilpr. from Wood's Bluff. The only essential difference seems to be that the Jackson form has the inner lip covered by callus on which there are numerous little prominences, while this callus does not exist in *F. subtenuis.*

68. A species in Jackson, *Turbinella humilior*, n. sp., differs from *Turbinella protracta* C. in being shorter and stouter and having a somewhat reflected canal. The two species agree otherwise; for instance the following marks at the mouth are common to both. On the inner lip there are three little prominent folds;

* In honor of my friend, the able and careful naturalist, Oscar Boettger, in Frankfurt a. M.

on the posterior part is a callous prominence; in a certain rather large distance from the outer lip there are seven elevated striæ within; at the beginning of the canal is a tooth-like prominence.

In the younger specimens from Jackson the canal is straiter than in the older ones.

69. In Jackson occurs a species, *Fulgur filius*, n. sp., which has the form of *F. Mississippiensis* C. from Vicksburg. The coarse part of the sculpture is also similar, but the surface is covered with fine, closely set, elevated revolving lines. In the largest of my Vicksburg specimens the following can be seen: In the youngest reticulated whorl there are only the large revolving lines, then a small line appears in the middle of the large ones and finally one more line appears in the interstices. If we imagine this process repeated twice more, we obtain the finely striated surface of *F. filius*, and indeed this same process can be traced along the whorls of the Jackson form, so that we can say, the young *F. filius* repeats the old *F. Mississippiensis*.

72. A Marginella in Jackson agrees essentially with specimens from Claiborne, which I determined as *Marg. incurva* Lea, but seems to be generally larger and much inclined to deposit callus on the posterior part of the mouth. It may be called *var. Jacksonensis*.

74. *Mitra dumosa* C., from Jackson, is more slender and ornamented than *M. pactilis* C., from Claiborne, but both qualities vary in both places and *M. dumosa* cannot be considered more than a variety.

75. One of the most difficult genera is Oliva. On one side the species vary very much, especially in form. Any doubt about this is removed by two specimens of a common species in Jackson, where the color is preserved. On the other hand it may be that different species in the fossil state are distinguished only by small differences.

I relate three species to each other, one from Claiborne, determined as *Oliva gracilis* Lea, the above mentioned one from Jackson, which is generally stouter, and *Oliva Mississippiensis* C., from Vicksburg, which is larger and again stouter and where the main inflation is generally somewhat higher. The Jackson species may be called *Oliva media*.

76. A specimen from Vicksburg, which may be Conrad's *Cancellaria funerata*, resembles much a specimen from Jackson (not the common Cancellaria). A disagreement in the third embryonic whorls, however, may indicate a different origin.

77. The Vicksburg species *Terebra divisura* C. is rather common in Jackson, but from Claiborne I have only one imperfect specimen. The variation seems to be mainly in the distinctness of the line below the suture.

78. The genus Pleurotoma, of which numerous species occur in the three deposits, must have varied or migrated very much at this time, or both. Two species look similar, *Pleur. Lonsdali* Lea from Claiborne and a species in Vicksburg (*Pleur. Mississip-*

piensis C. ?). But my material is not complete enough to allow a conclusion in regard to a relationship.

In Jackson occurs a species, *Pleurotoma exsculpta*, n. sp., which differs from *Pleur. tenella* C., from Vicksburg, in having the ornamentation, especially the transverse striæ, more distinctly worked out and the canal shorter. The length of the canal of *P. tenella*, however, varies a little and I consider the two species to be related.

79. *Conus tortilis* C. and *Con. alveatus* C. are only slight variations of *Conus sauridens* C.

80. In Vicksburg occurs a new species, *Conus protracta.* It approaches in its form the genus Conorbis. The lower part is almost like that of *Conus sauridens* C., but it is a smaller species. The spire is elevated, forming the third part of the shell, is without revolving lines and has one or two smooth embryonic whorls more than *C. sauridens.* In Jackson occurs a similar form but with revolving lines on the spire, *Conus Jacksonensis*, n. sp. Probably both species are to be related to each other.

81. A species in Jackson, *Actæon annectens*, n. sp., is similar and related to *Act. punctatus* Lea, but it is smaller, has a more regularly rounded form than the Claiborne species generally has, and the fine transverse striæ are less closely set. The largest specimen moreover has an indistinct second fold above the larger first one.

84. From Claiborne I have a complete specimen of Cylichna, which belongs to the subgenus Volvula. A similar or identical species occurs in Jackson. After a comparison with my specimens of *Bulla radius* Desh. I am inclined to identify the American and French species. What Gabb describes as *Volvula Conradiana* from Texas must be nearly allied or identical.

In the table *C.* stands for *Conrad*, *Mr.* for *Meyer.*

TABLE SHOWING THE SUCCESSIONAL RELATIONS OF THE VICKSBURG, JACKSON AND CLAIBORNE SPECIES. THE SYMBOL > SIGNIFIES DECREASING IN ABUNDANCE IN THE DIRECTION TOWARD WHICH IT POINTS, AND [ ] THAT THE RELATIONS ARE DOUBTFUL.

	VICKSBURG.	JACKSON.	CLAIBORNE.
		1. Foraminifera.	
1	Nodosaria obliqua *L.* sp.	Nodosaria obliqua *L.* sp.	Nodosaria obliqua *L.* sp.
		2. Bryozoa.	
2		Lunulites interstitia *Lea* sp.>	Lunulites interstitia *Lea* sp.
3		Discoflustrellaria Bouéi *Lea* sp. >	Discoflustrellaria Jacksonensis *Mr.*
		3. Corals.	
4		Turbinolia pharetra *Lea.* <	Turbinolia pharetra *Lea.*
5		Endopachys Macluri *Lea* sp.	Endopachys Macluri *Lea* sp.
6		Platytrochus nanus *Lea* sp.	Platytrochus nanus *Lea* sp.

	VICKSBURG.	JACKSON.	CLAIBORNE.
		4. Lamellibranchiata.	
7		Pecten Lyelli *Lea.* >	Pecten Lyelli *Lea.*
8	Pecten (Poulsoni *Morton?*)>	Pecten nuperus *C.* >	Pecten Deshaysi *Lea.*
9	Avicula Claibornensis *Lea.* (A. argentea *C.*)	Avicula Claibornensis *Lea.*	Avicula Claibornensis *Lea.*
10	Arca (Byssoarca) Mississippiensis *C.*	Arca (Byssoarca) Mississippiensis *C.*	
11	Arca (protracta *C.?*) sp.	Arca rhomboidella *Lea* var.	Arca rhomboidella *Lea.*
12	Pectunculus arctatus *C.*	Pectunculus arctatus *C.* (var.?)	Pectunculus arctatus *C.* (var.?)
13		Pectunculus Broderipi *Lea.*	Pectunculus Broderipi *Lea* var. filosus *C.* (*P.* filosus *C.*)
14		Limopsis radiatus *Mr.*	Limopsis obliquus *Lea* sp.
15	Nucula ovula *Lea* var. Vicksburgensis *C.* or? Nucula Vicksburgensis *C.*	Nucula ovula *Lea* (var. ?)	Nucula ovula *Lea.*
16		Leda mater *Mr.*	> [Leda plicata *Lea* sp.] > Leda mater *Mr.* (var. ?) [Leda media *Lea* sp.]
17		Astarte sulcata *Lea* var. Jacksonensis *Mr.*	Astarte sulcata *Mr.*
18		Astarte Nicklini *Lea.* var. parilis *C.* (*A.* parilis *C.*)	Astarte Nicklini *Lea.*
19	Astarte parva *Lea* var. Vicksburgensis *Mr.*	Astarte (Micromeris) parva *Lea.*	Astarte (Micromeris) parva *Lea*
20	Alveinus minutus *C.*	< Alveinus minutus *C.* >	Alveinus minutus *C.*
21		Venericardia planicosta *Lam.*	Venericardia planicosta *Lam.*
22		Venericardia diversidentata *Mr.*	Venericardia rotunda *Lea*
23		Venericardia parva *Lea* var. Jacksonensis *Mr.*	< Venericardia parva *Lea.*
24		Venericardia inflatior *Mr.* var. Jacksonensis *Mr.*	Venericardia inflatior *Mr.*
25	Crassatella Mississippiensis *C.*	?	Crassatella alta *C.*
26		Crassatella protexta *C.* var. flexura *C.* (*Cr.* flexura *C.*)	Crassatella protexta *C.*
27	Lucina Mississippiensis *C.*	Lucina Mississippiensis *C.*	
28	Lucina perlevis *C.*	Lucina perlevis *C.*	
29		Lucina papyracea *Lea.*	Lucina papyracea *Lea.*
30	Lucina sp.	Lucina sp.	
31	Cardium diversum *C.*	Cardium Nicolleti *C.*	
32		Cytherea minima *Lea.*	Cytherea minima *Lea.*
33		Cytherea Jacksonensis *Mr.*	< Cytherea Hydi *Lea.*
34	[Cytherea sobrina *C.*]		Cytherea comis *Lea.*
35	Tellina Vicksburgensis *C.* <	Tellina Vicksburgensis *C.* var. robusta *Mr.*	
36		Periploma Claibornensis var. parva *Mr.*	Periploma Claibornensis *Lea.*
37	Mactra (funerata *C.?*)	Mactra (funerata *C.* var. ?)	Mactra pygmæa *Lea.*
38	Mactra sp.	Mactra inornata *Mr.*	Mactra inornata *Mr.*
39		Corbula Willistoni *Mr.* <	Corbula gibbosa *Lea.*
40		Corbula Murchisoni *Lea* var. bicarinata *C.* (C. bicarinata *C.*)	Corbula Murchisoni *Lea.*
41		Corbula Alabamiensis *Lea* var. densata *C.* (C. densata *C.*)	Corbula Alabamiensis *Lea.*

	VICKSBURG.	JACKSON.	CLAIBORNE.
		5. Glossophora.	
42	Dentalium alternatum *Lea.* (D. Mississippiensis *C.*)	Dentalium alternatum *Lea.*	Dentalium alternatum *Lea.*
43	Dentalium microstria *Heilpr.?*		Dentalium microstria *Heilpr.*
44	Dentalium subcompressum *Mr.*	Dentalium subcompressum *Mr.*	
45		Dentalium Danai *Mr.*	Dentalium Leai *Mr.*
46	Cadulus Vicksburgensis *Mr.*	Cadulus Jacksonensis *Mr.*	[Cadulus compressus *Mr.*]
47	Teinostoma Verrilli *Mr.*	Teinostoma Verrilli *Mr.*	Teinostoma subrotunda *Mr.*
48		Solarium bilineatum *Lea.*	Solarium bilineatum *Lea.*
49		Solarium ornatum *Lea* var. acutum *C.* (S. acutum *C.*)	Solarium ornatum *Lea.*
50	Solarium triliratum *C.*	Solarium bellastriatum *C.*	Solarium Henrici *Lea*
51	Turritella carinata *Lea.* (*T.* Mississippiensis *C.*)	Turritella carinata *Lea.*	Turritella carinata *Lea.*
52		[Turritella alveata *C.*]	Turritella lineata *Lea.*
53	Trochita trochiformis *Lea.*	Trochita trochiformis *Lea.* (*T.* alta *C.*)	Trochita trochiformis *Lea.*
54		Hipponyx pygmæa *Lea*	Hipponyx pygmæa *Lea.*
55	Sigaretus Mississippiensis *C.*	Sigaretus Mississippiensis *C.*	Sigaretus striatus *Lea* sp.
56	Natica decipiens *Mr.*	Natica parva *Lea.*	Natica parva *Lea.*
57	[Natica (semilunata *Lea* ?)]	Natica semilunata *Lea*	Natica semilunata *Lea.*
58	[Natica Vicksburgensis *C.*]	Natica permunda *C.*	
59	Eulima sp.	Eulima sp. >	Eulima sp.
60		Rostellaria Lamarcki *Lea* (R. staminea *C.*) >	Rostellaria Lamarcki *Lea.*
61	Distortrix crassidens *C.*	[Distortrix Jacksonensis *Mr.*]	
62		Pseudoliva pyruloides *Lea* sp. var. perspectiva *C.* (P. perspectiva *C.*) >	Pseudoliva pyruloides *Lea* sp.
63	Buccinum Mississippiensis *C.*>	Buccinum Mississippiensis *C.*	
64	[Fusus altilis *C.*]	Fusus sp.	[Fusus spiniger *C.*]
65	Fusus Bœttgeri *Mr.* <	Fusus Bœttgeri *Mr.*	
66		Clavella humerosa *C.*	Clavella raphanoides *C.*
67	Turbinella perexilis *C.*	[Turbinella perexilis *C.*?]	
68	Turbinella protracta *C.*	Turbinella humilior *Mr.*	
69	Fulgur Mississippiensis *C.* sp.	Fulgur filius *Mr.*	
70		Voluta (Scapha) Parkinsoni *Lea* (Caricella polita *C.*)	Voluta (Scapha) Parkinsoni *Lea.*
71		Marginella semen *Lea.*	Marginella semen *Lea.*
72		Marginella incurva *Lea?* var. Jacksonensis *Mr.*	Marginella incurva *Lea?*
73	Mitra conquisita *C.*	Mitra conquisita *C.* (M. Mellingtoni *C.*)	
74		Mitra pactilis *C.* var. dumosa *C.* (M. dumosa *C.*) >	Mitra pactilis *C.*
75	Oliva Mississippiensis *C.*	Oliva media *Mr.*	Oliva gracilis *Lea?*
76	[Cancellaria (funerata *C.*?)]	Cancellaria sp.	
77	Terebra divisura *C.*	Terebra divisura *C.*	> Terebra divisura *C.*
78	Pleurotoma tenella *C.*	Pleurotoma exsculpta *Mr.*	
79	Conus sauridens *C.* (C. alveatus *C.*)	Conus sauridens *C.* (C. tortilis *C.*)	> Conus sauridens *C.*
80	[Conus protracta *Mr.*]	Conus Jacksonensis *Mr.*	
81		Actæon annectens *Mr.*	Actæon punctatus *Lea.*
82		Actæon lineatus *Lea.*	Actæon lineatus *Lea.*
83		Cylichna Dekayi *Lea* (var. ?)	Cylichna Dekayi *Lea.*
84		Cylichna confr. radius *Desh.*	Cylichna confr. radius *Desh.*

ART. LX.—*On Meteoric Iron from Trinity County, California;* by CHARLES UPHAM SHEPARD.

FOR my knowledge of the meteorite here described I am indebted to Col. Joseph Willcox, of Philadelphia, who incidentally mentioned to me last autumn that he had seen some years ago a metallic mass at Holmes' Hole, Mass., brought from California, that he suspected to be of meteoric origin. It was in the possession of Captain C. W. Davis, who procured it ten years ago at Canyon City, in Trinity County. Through the kindness of Mr. A. F. Crowell of Wood's Holl, a few grams were obtained from Captain Davis for examination and analysis; the result of which has been that the meteoric origin, at first regarded as doubtful, has been established.

The first portions that were detached had the appearance of pure limonite; but were afterwards proven to contain minute particles of nickeliferous iron, whereby small fragments were readily attracted by the magnet. The thickness of the crust affording this limonite must have been at least a tenth of an inch; whence it may be inferred, that the meteorite had originated in a very ancient fall. The specific gravity of the limonite was between 3·81 and 4·04. It was compact, but yielded to pulverization, with exception of occasional very fine metallic grains, that flattened slightly by extreme pressure under the pestle. The application of the magnet took up more than half of this powder, which principally consisted of the limonite. It was thus found to be impossible to separate it from the metallic portion. An approximate separation of the two substances, however, was effected by HCl in the cold; and though the combination of them was not uniform, the nickel-iron was determined in one instance to be at least 10 per cent.

Two small fragments of the nearly unaltered interior were supplied for analysis. In these the coarsely grained crystallization was apparent, affording cleavable crystals of the octahedral form, similar to what is found in the Putnam Iron, that of Cocke County and others. The specific gravity of these fragments was 7·1, which is less than the average of meteoric irons, a circumstance to be expected from slight adhesions of hydrated peroxide of iron. To the same reason also is ascribable the considerable loss in the subjoined analysis:

Iron	88·810
Nickel	7·278
Cobalt	0·172
Phosphorus	0·120 = 96·380

For want of material no search was made for tin, copper, or manganese. No sulphur was present in the portions examined. The weight of the mass is nineteen pounds. Its shape is oval, somewhat flattened, with numerous elongated depressions.

Charleston, S. C., April 16, 1885.

ART. LXI.—*The Potsdam Group East of the Blue Ridge at Balcony Falls, Virginia;** by H. D. CAMPBELL.

BALCONY FALLS is the name given to a succession of rapids in the gorge through the Blue Ridge by which the James River finds its way from the valley to Piedmont, Virginia. There is no other locality in Virginia where the Potsdam formation is better exposed than at this point. All of its strata are cut through by the river. The accompanying map and section are designed to throw a clearer light upon the topography and geological structure of the region.

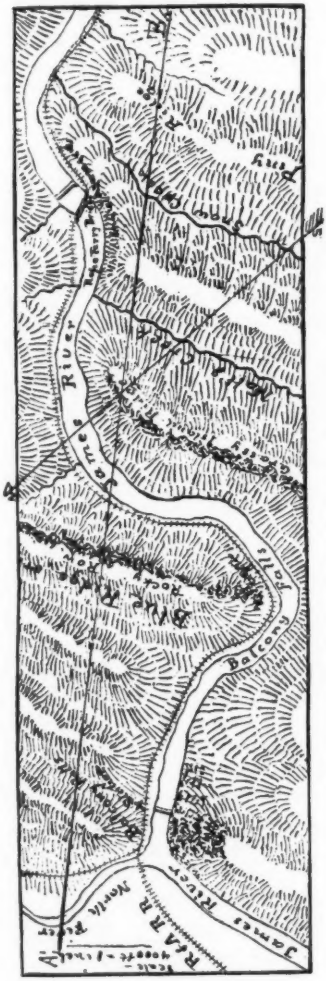
The Blue Ridge has been here sculptured into seven ridges, the middle one of which is the most clearly defined and alone has a granite axis. This is the Blue Ridge proper. On the map it is called Rocky Row on account of a very bold escarpment of sandstone upon its southeast face. The three ridges lying northwest of it are each crested with sandstone, and have been formed by the disintegration and washing away of the intervening slates. As seen from the river they appear as peaks with depressions between them. The ridges lying southeast of Rocky Row run rather obliquely across the beds of sandstone, and the intervening ravines have been formed by the erosive power of streams several miles in length, such as Matt's Creek and Snow Creek.

Geology.—The section is meant to be somewhat general, and hence the local displacements are left out, which makes the strata appear thicker than they are in reality. It represents an immense broken arch, or anticline, of Potsdam sandstones and slates, followed to the southeast by a trough or syncline of the same.

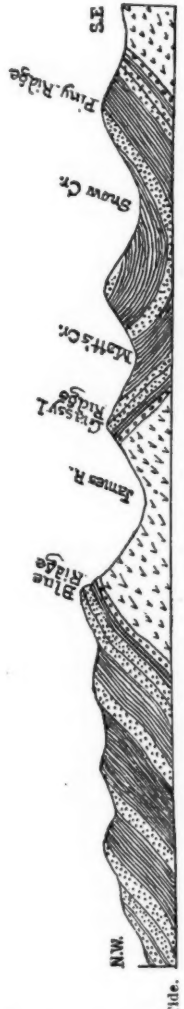
For about a mile after entering the gorge through the mountains the James River runs almost at right angles to the strike of the strata. Here and there it has washed away the softer slates and caused local displacements of the sandstones on either side, its waters having for a long time been dammed back by the lowest heavy bed of Potsdam sandstone, which is very hard and durable. Where the river crosses this ledge are the rapids known as Big Balcony Falls. Before the canal was built (along the bank of which the Richmond and Alleghany Railroad now runs), the ledge of sandstone projected considerably beyond the margin of the river, and was known as "Balcony Rock," hence the name of the falls. For about a mile after passing Balcony Rock the river runs obliquely across the strike. By its erosive power, aided by a fissure, and probably by ice also, it has worn its channel deep into the underlying

* A short paper upon this subject appeared in this Journal, Sept., 1884.

Archæan rocks, consisting of granulite, syenite and rocks of a gneissoid character. The river then leaves the mountains about at right angles.



Map of the James River Gorge at Balcony Falls, Virginia.



Scale, 4,000 feet = 1 inch.—Vertical Section along the line A–B on the Map.

The sandstones and slates from these Archæan rocks to the western limit of the gap have been classed as Potsdam or Lower Cambrian. Starting from the Archæan axis of the

Blue Ridge and proceeding northwestward up the river we cross the following series of beds:

No. 1 is a bed of conglomerate composed of sand, rounded quartz pebbles, fragments of feldspar and epidote and other material more or less water-worn. This bed is immediately followed by several beds of slates and conglomerate sandstones which have evidently been much altered by heat from the subjacent igneous rocks. The aggregate thickness of these beds is above 120 feet.

No. 2 is a heavy mass of sandstone about 360 feet thick. It consists of two varieties. The lower bed is a hard gray quartzite and is the material of the Balcony Rock. The upper bed is of a grayish and purplish color and finely conglomeritic in texture.

No. 3 consists of dark colored slates with interstratified beds of specular iron ore of low grade, having pebbles of quartz disseminated through them. The thickness of these slates is about 500 feet.

No. 4 is a hard bluish sandstone 150 feet thick, which has been locally displaced near the river, forming several waves that are conspicuous from the railroad. This feature is not represented on the section.

No. 5 is a heavy bed of bluish and greenish slates about 700 feet in thickness. They have been considerably warped and contorted.

No. 6 consists mostly of a brownish gray sandstone with very regularly jointed structure—90 feet thick.

No. 7 is made up of numerous thin beds of slate which produce a variety of shades of color from nearly white and yellow to dark brown. The coloring is produced by iron ore which encrusts many of the thin beds. The thickness of these slates is 120 feet.

No. 8 is the sandstone that constitutes the type of this formation. It consists here of two hard beds of gray sandstone with a more brittle bed intervening. The two hard beds carry numerous markings at right angles to the stratification, supposed to be borings of a worm called *Scolithus linearis*. These three beds, together with some more brittle sandstones underlying them, measure 350 feet. We have now arrived at the entrance of the gap. If we go away from the banks of the rivers some distance we shall find about 600 feet more of sandstone and friable slate before we get to the limit of the Potsdam formation.

Passing now to the eastern slope of the Blue Ridge we find similar beds of sandstone and slate which have been hitherto classed as Archæan by Professors Wm. B. Rogers, J. L. Campbell and others, and have been spoken of as lying unconformably beneath the Potsdam sandstones and slates of the western

slope. In Macfarlane's Railway Guide (1879, p. 182) we find the following note by Professor Rogers: "About twenty miles northwest of this point (Lynchburg) by canal or road, we enter the gorge by which the James River traverses the Blue Ridge, where are exposed fine sections of Archæan rocks, A and B, and of the Cambrian, Primal 2*a*, resting unconformably on the western slope of the former, and occupying the flanking ridges which adjoin the valley."

It is with diffidence that I offer my views as opposed to these, making (as seen in the section) an anticline here instead of unconformability; and yet I feel confident that the highly metamorphosed condition of all the rocks east of the Archæan axis, and the hurried review of this locality, led these geologists to place these sandstones and slates as Archæan, and that if the facts which I shall present had been known our views would coincide.

The evidences in support of the section I have drawn are as follows. Rocky Row on the north side of the river is capped with a hard sandstone of a grayish color dipping gently toward the northwest. Grassy Island Ridge, on the south side of the river, is capped with a sandstone of similar appearance, though not so thick, dipping about 40° S.E. Each of these beds of sandstone is underlaid by a brownish decomposing slate, and a bed of coarse conglomerate which lies upon the Archæan rocks. To the N.E. of the river about four miles and again to the S.W. about one mile these strata seem to connect and make a complete anticline. But this might seem to be the case where there is unconformability and hence we need stronger proof.

In all of the heavy beds of sandstone in the Potsdam group of the Blue Ridge above the lowest, *Scolithus* borings are found, varying in abundance in different localities, and being always more numerous in the higher beds. These markings have determined the age of the rocks along the western slope, together with their stratigraphical position. They occur here only in the upper beds, No. 8; but at White's Gap some miles N.E., they occur in abundance in the next lower bed of sandstone. Going now east of the axis of the Blue Ridge and examining the sandstones along the ridge between Matt's Creek and Snow Creek we find unmistakable *Scolithus* borings. These sandstones are conformable with that on Grassy Island Ridge. Proceeding up Matt's Creek we cross two of these beds, each carrying Scolithus borings. Between them lie heavy beds of slate, and in the first of these is found a bed of hematite ore similar to that mentioned above as occurring on the western side of the Blue Ridge and locally known as "block ore" on account of breaking readily into cubical and

rectangular masses. This variety of ore in Virginia seems to be characteristic of the Potsdam formation. Cresting the ridge on the left, in ascending Matt's Creek near its source is found a white sandstone of firm texture containing Scolithus borings. It has a dip of 45° S.E. which carries it across the head of Snow Creek to the crest of Piny Ridge which is not so elevated.

If we cross James River and follow the eastern face of the Blue Ridge toward the N.E. for several miles we find sandstones carrying Scolithus markings and beds of slate alternating with them, all dipping S.E. They correspond very closely in character and position with those described to the south of the river. Three miles N.E. of Rope Ferry a bed of these slates is quarried by the Virginia Slate Mining Co. for roofing purposes. They are somewhat different lithologically from the corresponding slates along the western slope of the Blue Ridge, being much more highly metamorphosed and hence having a more perfect cleavage.

The foregoing observations led to the conclusion that the stratified rocks upon the western and eastern slopes of the Blue Ridge belong to the same geological formation, and that the latter ought to be classed as Potsdam or Lower Cambrian instead of Archæan. This would make of the Blue Ridge an immense broken arch at Balcony Falls.

This broken arch or anticline is immediately succeeded by an unbroken syncline about two miles in width, near the axis of which is Rope Ferry Bridge. How far on either side of the river this syncline may extend we have not yet fully determined. The upper beds of sandstones and slates do not make their appearance for some distance on either side of the river, having probably been somewhat broken in their upheaval, and washed away before the river became confined to its present narrow channel.

It seems more than probable that ice was one of the great agents in determining the features of this region.

To the east of the syncline mentioned above we find Archæan rocks again represented by granite and gneiss. This corresponds to the axis of Cold Mt., which is a ridge lying several miles S.E. of the axis of the Blue Ridge and parallel with it. A few miles N.E. of this locality Cold Mt. is very high and conspicuous.

From what has been written above, the general conclusion may be drawn that the belt of sandstones and slates lying east of the Blue Ridge at Balcony Falls belongs to the Lower Cambrian or Potsdam group of rocks, and that the Primordial beach of the Palæozoic Sea was farther east at this locality than was formerly supposed.

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ART. LXII.—*Geology of the Sea-bottom in the approaches to New York Bay;* by A. LINDENKOHL, U. S. Coast and Geodetic Survey. With a plate (Plate IV, unnumbered).

[Read at the meeting of the National Academy of Sciences, April 22, 1885, by J. E. HILGARD.]

DURING the survey of the sea-approaches to New York in the years 1842 and 1844, specimens of sea-bottom were collected while soundings were in progress. The samples were examined under the direction of Professor Bache by Assistant L. F. Pourtales of the Coast Survey Office and by Professor J. W. Bailey of West Point, N. Y., and the results of analyses were published as Appendix No. XI with the Coast Survey Report for the year 1869. The investigations by these naturalists attracted attention and ended in opening the way to a field of scientific inquiry which, at this time, is cultivated by men eminent in such researches in all the leading nations. Neither of the naturalists here named is now living.

Within the last five years, minute hydrographic surveys have been made of the same locality. Some collateral information also has been furnished by the Geological Survey of New Jersey under the direction of Professor George H. Cook. We are thus enabled to invest deductions with increased precision, and to extend inquiry beyond the limits to which Assistant Pourtales restricted himself.

The sea-bottom off the entrance to New York lower bay is characterized by features peculiar to that region. These include:

1. A well defined submarine valley.
2. An area of clay bottom extending about one hundred miles seaward.
3. A deep ravine at the edge of the continental slope.

The features here specified will be separately described.

Submarine Valley.—The early survey of the sea-approaches to New York developed the existence of a series of "deep mud holes" lying in a straight line off the entrance. These it was supposed might serve as guides to mariners, but no special significance was attached to the "mud holes" until Professor Dana, from a study of the Coast Survey soundings, showed that they lay in the course of a valley-like depression which had the right position to have been, in a period of higher level, the continuation of the Hudson River channel. When these views were communicated to the Coast Survey Office these mud holes were at once recognized as indications of such a channel, and it was surmised that they actually form a continuous channel instead of being separated. The last survey

has developed the existence of this channel; and thus the question is opened—whether this channel was produced by a break in the strata as was the upper channel of the Hudson, or by the current of a river seeking an outlet to the ocean. The following facts bear upon the question.

The first indications of the channel are found ten nautical miles east by south off Sandy Hook at a depth of 19 fathoms. After following a southerly course for about ten miles, the channel takes an easterly turn in the next five miles; from the distance of fifteen miles (twenty miles in a direct line from the Hook) it maintains a straight course (60° S. E.) to its bar, which is eighty miles from the Hook.

From the head of the channel to the bend, the top of the banks remains at about an even level of 18 fathoms depth, while the channel increases in depth from 19 fathoms to 36 fathoms. The average slope of the banks is one degree, and the width of the enclosed channel from three quarters of a mile to a full mile; in the bend this slope is increased to three degrees, and the width contracted to one eighth of one mile.

The banks maintain the same height on both sides, and are, as also is the bottom, composed of a sandy clay overlaid by a crust of sand and gravel which spreads continuously over the adjacent flats. This clay is very uniformly described by the surveyors as "blue clay" in the upper channel and "green mud" in the lower channel. The bar (at seventy-five nautical miles from the Hook) is composed of fine sand. At the distance of eighty-five miles the channel reappears as a deep ravine and it will be described separately. The cross sections of the channel, at intervals of ten miles starting from Sandy Hook, taken from the recent survey, are here given:

Distance naut. miles.	Depth of channel below sea level in fathoms.	Distance from top of clay bank to sea level in fathoms.	Height of banks in fathoms.
10	25	17	8
20	35	20	15
30	37	22	15
40	42	27	15
50	41	30	11
60	43	36	7
70	43	38	5
(75)	(41)	(39)	2
80	43	43	0

From this exhibit we may infer that the channel has been produced by erosion and its present shape is due to the action of flowing water. The mud brought up by the lead has not been deposited upon the sea bottom by precipitation, but is the actual soil which is a stratum of clay which must have a thickness of over ninety feet.

This sandy clay is believed to be identical with the Tertiary

"sandy clay strata" of the New Jersey geological survey which underlies nearly the whole of the peninsula of lower New Jersey.

The disappearance of the submerged valley at a less depth than 19 fathoms must be attributed to the obstructive action of Sandy Hook bar. By taking this depth as the greatest ever reached by the channel over the bar near Sandy Hook, we can form an estimate of the geological age of this bar.

Professor Cook, in a statement made before the Riparian Commission of New Jersey, November 17, 1883, estimates the present rate of subsidence of the coast of New Jersey at about two feet in a hundred years. At this rate, the decrease of depth from 19 fathoms to 4 fathoms which is about the present mean depth of the New York bar, would cover a period of four thousand five hundred years.

The transfer, per saltum, of a bar at the depth of 41 fathoms and at a distance of 75 miles from the Hook to one of 19 fathoms depth and in the immediate vicinity, however, cannot well be explained upon the theory of such a gradual and moderate subsidence as is believed to be going on at the present time.

The State Geologist, Professor Cook, assuming a mean dip of twenty-five feet to the mile for the marl beds, has indicated lines of strike upon his geological map, showing the depth below sea level of the red sand bed (a subordinate stratum of the Cretaceous marl formation) and the lines A and B on the map (see Plate) are such lines for the depths respectively of 250 feet and 1040 feet. These lines produced to the submerged channel strike the top of the clay bank at points the respective depths of which are 108 and 162 feet below the ocean level. This great difference in dip (790 feet against 54 feet) may be accounted for by supposing that the top of the clay bank does not coincide with the line of stratification (its slope being about two feet to the mile), or there may be a flattening out of dip toward the sea. And, again, the sandy clay bed may not rest conformably on the formations which crop out on the dry land.

In the geological surveys of Pennsylvania and New Jersey, the terminal moraine was accurately traced through these two States, and the sketch shows its course from the valley of the Alleghany in western New York, eastward and southward to New York Bay. The line as there shown was taken from a map by Professor Lewis in this Journal, 1884; and from the geological map of New Jersey, 1882. It will be seen at a glance that this line and the submerged valley of the Hudson form a continuous line, and this coincidence suggests that this valley stands as a mark of the limit of the glacial drift and as one of the "great waste-weirs of the melting glacier," to use an expression which Professor Lewis applies to the Lehigh

river. The range of hills which traverses Long Island from the New York Narrows to Montauk Point has been recognized as a well developed glacial moraine, and Professor Cook has established its lateral connection with the New Jersey moraine by way of the southern part of Staten Island. Now if the contemporaneous existence of these two moraines could be proved, it would follow that the south end of Staten Island was the most advanced point of the glacier. Professor Chamberlin has very recently (in a contribution to the Annual Report of the U. S. Geol. Survey, 1882–83) made the relative ages of these two glaciers the subject of a careful study. For our present purpose it will suffice to state that the Long Island moraine, by reason of its great boldness, which implies a period of powerful glacial action, bears a greater resemblance to the more northerly moraines of the interior than to the terminal moraine which stands as the extreme advance of a gradually receding glacial drift. This circumstance alone warrants the assumption that the terminal moraine must be looked for to the southward of Long Island.

Clay Bottom.—Assistant Pourtales drew attention to a large area of muddy bottom off the eastern end of Long Island, and remarked also upon the scarcity of remains of animal life in the specimens of bottom from this region. That muddy bottom zone is interposed between the wide sand belt which skirts the coast and the deep sea ooze which is of calcareous nature and which covers all the deeper bottoms of the ocean. By careful study of the soundings, including those recorded by the U. S. Fish Commission, we are enabled to trace the outline of this formation. It is triangular; the base D E (see plate) coincides nearly with the line of 1000 fathoms and reaches from the latitude of Cape Charles to the longitude of Cape Sable. The apex (F) lies about ten miles southeast of Block Island, but a narrow strip of muddy bottom can be traced still farther north, nearly to the western end of Martha's Vineyard.

Assistant Pourtales says (C. S. Report for 1869, Appendix XI), "The mud or ooze had its origin probably in the Tertiary formation, of which we see only the remnants in the cliffs of Gay Head, and in a few localities of small extent on the coast of Massachusetts, as at Marshfield or elsewhere." . . . "A similar sea bottom is found in the so-called mud holes off the entrance to New York. They are depressions below the general depth of the surrounding bottom, filled with mud." These expressions do not render it clear to me whether he considered this mud to be sediment or true soil; but judging by the uniformity and the magnitude of its range, since the greater part if not the whole of the mud in question is either clay or corroded clay, we recognize in it the traces of a great geo-

logical formation having a vertical range of nearly six thousand feet. The sea-bottom within this area may contain the outcroppings of strata of various composition and of different ages, but these strata must be assumed to be always more or less argillaceous. The shoaler soundings generally show a strong admixture of sand while the deeper ones appear as purer clays. At about the depth of 1000 fathoms the clay gives way to the globigerina ooze; but in some instances clay has been found by the Fish Commission at depths over 1500 fathoms. In view of the fact that in coast regions the distribution of "sand" and "mud" bottoms is very often the result of ocean currents, it appears proper to define the extent to which such currents may have affected the limits of our "clay region."

We may freely admit that, in moderate depths, currents may disturb and shift the material of the bottom and may also change its mineral composition by the introduction of sediment washed out to sea, but such changes cannot take place at great depths nor at great distances from the coast and could have affected but a very limited part of the clay bottoms. The only agency which could change the geological structure of the sea bottom at the depth of the main part of the clay region, we take to be precipitation of very fine material held in suspension by the sea water; but the effect of such precipitation would be to obliterate existing geological distinctions rather than to render them more apparent.

A line drawn from Trenton to Jersey City separates the clay region from the red sandstone region. This line is about one hundred and fifty miles from the curve of one thousand fathoms. Hence, if we assume these two lines to be on one plane of stratification, the dip of the strata would be forty feet to the mile. It appears quite plausible to assume that the dip of pliable strata which is found to be decreasing in the coast region should show an accelerated increase when it approaches the continental slope.

It has been suggested by Professor Dana and is so stated in Dana's "Manual of Geology," 2d edition, p. 537, that the lower limit of the New England part of the terminal moraine probably coincided with the outline of the deep water slope, about 80 miles south of Long Island and outside of St. George's Shoal. Now, the clay bottom region being bare of drift, we can safely assume that the lines F D and F E indicate the extreme limit of glacial drift on this part of the continent. The thickness of the cover of diluvial drift in the vicinity of the submerged valley appears to be at the utmost about sixty feet.

The Hudson River Fiord.—The deep ravine mentioned above as one of the remarkable features of the sea-approaches to

New York lies in a nearly straight continuation of the submarine channel and reaches from the outer end of the bar already mentioned, or about eighty-five miles to seaward from Sandy Hook, to the edge of the continental slope at a distance of about one hundred and five miles from the Hook. This ravine is about twenty-five nautical miles long and three miles wide. It commences with a depth of about sixty fathoms below the ocean's surface which increases to two hundred fathoms within the first mile; the greatest depth, four hundred and seventy-four fathoms, is close to its outlet. This outlet to the ocean is in the shape of a bar with a depth of about two hundred fathoms. For half its length, from its middle to the bar, this ravine maintains a vertical depth of more than two thousand feet, measuring from the top of its banks; these banks have a nearly uniform slope of about 14°. It remains to be stated that the bottom and the sides of the ravine are composed of a green sandy mud, and that the adjacent flats, unlike those of the submerged channel, show the same material.

The absence of signs of violent action in the region of this depression precludes the supposition that it is a fissure; on the contrary its position at the lower limit of the glacier, its shape, and its direction, render probable the supposition that it belongs to the class of fiords so common to higher latitudes. If we so conclude, the question cannot be avoided—why is the continuity of the submerged channel interrupted by a bar. The borings at Cape May, at Atlantic City and elsewhere along the New Jersey sea border carried down to depths of two hundred feet or more, do not show any harder strata than clay. Hence there is no reason to assume that this bar was induced by a rocky obstruction. It appears more plausible to suppose that the fiord belongs to an earlier time when the river made its channel to the sea through ice obstructions, and that the submerged channel farther up is of a later period, when the passage to the ocean was free and the régime of the river was well established.

ART. LXIII. — *Additional Notes on the Kettle-Holes of the Wood's Holl Region, Massachusetts;* by B. F. KOONS.

DURING the summer of 1884, in connection with my work for the United States Fish Commission at Wood's Holl, I extended my observations, as far as opportunity offered, on the kettle-holes in the Vineyard Sound region, partly to revisit localities studied the year before (and complete work then left unfinished), and in part to give wider range to recorded facts.

Soon after my former article appeared in the Journal of Science, April, 1884, numerous inquiries were made by various geologists of the United States, showing a much wider interest in the subject than had been anticipated, and some of these questions bore upon points not particularly studied, while others asked for further explanation of facts there recorded. A part of these questions have been answered by letter, and in the following notes I shall aim to reply to the remainder either directly or indirectly. The previous article gave my observations made upon the east end of Naushon, the point of the main land, and the intervening islands, about twelve miles in extent, and sixty-four kettle-holes were located and described; and in the later observations a territory extending from Robinson's Holl on the west to a point several miles north of Falmouth village, over twenty miles in all, was visited, and I here give the measurements for forty-two additional.

On the Island of Naushon.

No.	Direction of long axis.	Length of long axis.	Length of short axis.	Height of highest border.	Height of outlet.	Position of outlet.
65	N. 50° E.	20 rods.	7 rods.	25 ft.	8 ft.	S.W.
66	N. 55°–60° E.	25	15	30	15	S.
67	N. 50°–55° E.	20	16	30	10	S.W. by W.
68	N. 55° E.	20	12	25	12	N.W. by W.
69	N. 40° W.	20	8	73	31	S.E.
70	N. 25° E.	10	8	30	22	S.W.
71	N. 50° E.	8	5	35	8	N.E. by N.
72	N. 80° E.	25	10	45	30	S.W.
73	N. 15° E.	18	7	30	12	N.E.
74	N. 50° E.	18	7	70	30	N.E.
75	N. 70° E.	7	5	65	20	S.E. by S.
76	N. 50° E.	25	8	48	20	E. by S.
77	N. 60° E.	12	10	40	12	N.
78	N. 60° E.	25	18	60	20	W.S.W.
79	N. ———	20	20	30	20	S.
80	N. 80° E.	18	7	48	18	S. by W
81	N. 80° E.	18	8	49	20	S.
82	N. 80° E.	45	10	65	25	N. by W.
83	N. 90° E.	7	4	18	10	N.N.E.
84	N. 70° E.	45	16	60	25	N.E. by N.

On the mainland east of Wood's Holl.

85	N. 35° E.	16	6	35	13	S.W. by S.
86	N. 20° E.	45	8	60	12	N.E. by N.
87	N. ———	25	9	45	25	N. by W.
88	N. 5° W.	10	6	38	16	S. by E.
89	N. 50° E.	34	10	40	20	S. by W.
90	N 45° E.	20	12	25	10	E. by N.
91	N. 20° E.	30	20	80	35	S.S.W.
92	N. 90° E.	40	10	90	30	S.E. by E.
93	N. 80° E.	8	4	75	8	S.E. by S.
94	N. 40° E.	32	7	70	35	S. by E.
95	N. 60° E.	50	30	40	10	W.
96	N. 40° E.	18	10	90	25	N.W.

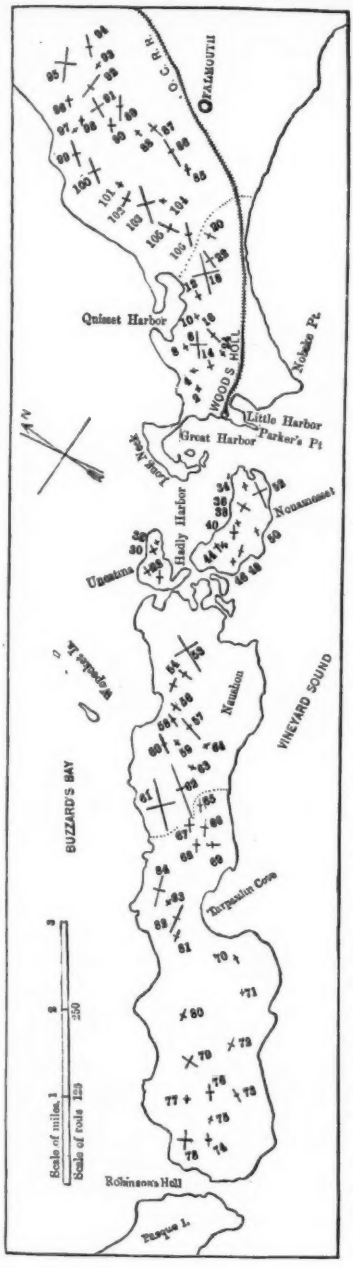
On the mainland east of Wood's Holl—continued.

97	N. 80° W.	8	4	60	12	E. by N.
98	N. 45° E.	12	5	60	12	N.E. by W.
99	N. 30° E.	40	12	100	50	N.E.
100	N. 45° W.	40	20	80	30	N.E.
101	N. 10° W.	8	4	30	12	N. by W.
102	N. 80° E.	23	8	40	15	N.E. by E.
103	N. 35° E.	55	28	75	45	E. by N.
104	N. 35° W.	10	6	25	12	S.E. by S.
105	N. 10° W.	30	9	70	20	
106	N. 45° E.	35	7	50	10	

However, these represent certainly less than one-tenth, possibly less than one-fifteenth of all that are to be found within the region examined. Upon further examination I find that while there are large numbers upon the south slope of the moraine, and some too of very large dimensions, yet by far the greatest number and the largest are upon the side from which the glacier came, and this is what we should expect if the kettle-holes mark the localities where fragments of ice were broken off from the face of the glacier and buried, wholly or in part, by the earth and stones borne down by the ice-sheet. Also the direction of the longer axis is just what we should most naturally expect in kettle-holes made by such ice-masses. Certainly they are not uniformly parallel to the face of the glacier, nor would we expect them to be so; yet an examination of the map and tables accompanying this and the former article will show that their general direction approximates to this.

One inquirer asks, "Are the basins on the crest of the moraine more frequently transverse to, and those on the inner slope more apt to be parallel with, the moraine or following the configuration of the country toward outlets or gaps through the moraine?"

Upon a careful examination of the facts, both in the field and those of formerly recorded measurements, I fail to discover any such law. The question was asked in the light of the possibility of the kettle-holes being made by streams of water pouring from the face of the glacier and eroding along the lines of freest discharge, somewhat after the manner of streams of the present, gouging out deep holes along their beds which are connected by very shallow rills at low water: or, as often occurs in western streams in dry seasons, leaving deep holes as small ponds or pools with no water flowing from one to the other. No such arrangement can be made out among the kettle-holes of this region for they are distributed singly and in groups without any connection or arrangement indicating that they were made by torrents of flowing waters. At one point on the south side of Naushon, in an open space near Tarpaulin Cove, there are twelve or fifteen of medium size, very closely packed together, and so completely without arrangement



that they seem to have no relation whatever one to another; and many other localities are quite as remarkable for the great number and size of their kettle-holes. Often when two of these depressions are near each other the highest border of each is between them and their outlets in opposite directions. And again it is often found that the slope of the outlet is even as high as 30°, which would preclude the idea of flowing waters making them; for it would be very difficult to secure such a flow of waters as would scoop out a cavity on so gigantic a scale as some of these kettle-holes and carry the material up an inclined plane several rods in length at an angle of over 30°, possibly 40°, for some of them were of the steeper angle when made. And further, if they had been scooped out by water, and the mud and fine material carried away they would have been left at least partly filled with bowlders, but the bottoms and largely the sides are quite free from them. Those found at the bottom of the depressions have probably been exposed by erosion and then rolled down from some of the surrounding slopes, for the washing of material from the sides into the pits during the ages since the Glacial period would be sufficient to expose the bowlders as we find them now.

Nor does an examination of the general arrangement of the outlets to the kettle-holes (by the outlet I mean the lowest point in the rim), indicate

that flowing water made them, for often if they were made in this way the water must have found its way directly back into the face of the glacier if the lowest point is any indication as to the direction of the flow.

We find kettle-holes also below sea-level. There is one in Great Harbor, at Wood's Holl, nineteen fathoms deep with shallow water all around; and it is said that it has been gradually filling within the memory of men. One in Vineyard Sound is forty fathoms deep with the water only ten on its borders. Professor Verrill also informs me of another off Cape Ann ninety fathoms deep while the water about is from thirty to forty.

Upon conversing with the various naturalists of our United States Fish Commission corps who are familiar with the geological features about Vineyard Sound, and more especially Professors Baird and Verrill, they express themselves very decidedly of the opinion that flowing water could not be the agency that made them. "The structure, arrangement, and all their features utterly preclude the idea." Also Professor Linton, who has accompanied me each year in a part of my studies, is of the same opinion.

There is one place between Wood's Holl and Falmouth, however, where it is very evident that a stream did flow to the south from among the hills, and the bed and sides of this are very different from the ordinary slopes and bottom of the kettle-holes. The former are almost paved with bowlders just as we should expect to find them in the bed of a stream flowing through such material as the glacial drift, while, as stated above, the kettle-holes are quite free from them.

There are also evidences two miles west of Tarpaulin Cove, on the south side of Naushon, that a glacial stream, of no mean proportion, swept from among the hills in the center of the island into Vineyard Sound. The exact windings of the stream are easily traced, and just to the west of its mouth stratified deposits are found cropping out in the bluff seventy-five feet above mean tide; but this river channel, unlike the one found on the mainland east of Wood's Holl, has few bowlders in it because of the fineness of the material composing the west end of the island, and the notable absence usually of large rock fragments especially at this point.

Stratified deposits composed of clay and sand more or less fine are found in various other localities. Beyond Quisset Harbor nearly to the extreme northeast point visited, a finely laminated clay bed several feet in thickness and covering considerable area is found with no coarse material over it but large bowlders near by. At several points on the road between Wood's Holl and Falmouth thin beds of stratified material are found, one of which dips at an angle of about

thirty degrees; but most likely this is due to local displacement, perhaps a sliding of a bank rather than a general disturbance of the surface of the region. These stratified deposits are found in a great many localities, both upon the mainland and the islands, and often upon the highest points of the region; the most extensive of all (described in my former article) are upon the very summit of Naushon over two hundred feet above the sea. At times they are overlaid by coarse unmodified drift, at others occupy the surface; and upon a study of the localities and the character of the deposits it seems that they were made by the flowing waters of the streams as they ran from the face of the glacier and found their way over the terminal moraine into the sea beyond.

Doubtless the borders of the kettle-holes were much higher at the close of the Glacial period, and the depressions themselves much deeper; and perhaps we can safely add one-third or one-half to the measurements; and, as mentioned elsewhere, the angle of the slope has been much reduced; however, no excavation or railroad cut has yet afforded an opportunity for the examination of the formations at the bottom of these depressions.

It will be noticed that just east of Quisset Harbor the general direction of the long axes changes, and instead of having the same trend with those on the Elizabeth Islands and the point of the peninsula near the village of Wood's Holl, it swings around toward the north to about N. 25° or 30° E.; and just here Mr. Warren Upham made an angle in the terminal moraine.*

Clarence King, Mr. Upham and others make the Elizabeth Islands and the line of hills about Wood's Holl, Falmouth, Quisset, etc., a portion of an inner moraine, and Martha's Vineyard, Nantucket, etc., marking the outer. I have not been able to devote any time to the study of the outer moraine upon the islands except to note a few features of No Man's Land. It has been asserted, but certainly by those who have not examined the island carefully, that the south shore is in large part made up of ledges, but a visit failed to discover them. However clear evidences of large beds of stratified material, doubtless of the so-called Tertiary, similar to some of those at Gay Head at the west end of Martha's Vineyard, extend along the south shore in a cliff seventy-five feet high, with a layer about five feet thick of very coarse unstratified material upon the top. These stratified beds have a strike of N. 50° W., dip 25° N.E. There are also stratified deposits cropping out along the east side of the island, and the encroachments of the sea upon that part of the shore show the

* This Journal, III, vol. xviii, p. 203.

edge of a considerable deposit of peat in a depression some forty feet above the sea. We were informed by one well acquainted with the island that a pole thrust down into it shows the bed to be twenty feet thick.

Remote from the sea, upon Naushon and the other islands, there are found large numbers of shells of both lamellibranch and gasteropod mollusks, often unbroken, and even the valves of the lamellibranchs not separated, the carapaces and at times whole crabs, shells of barnacles, etc., which are carried there by the birds, more particularly by the crow, as it is found that they depend largely upon these animals for their food. Doubtless these animal remains are buried and preserved by the drifting sands, and this fact possibly should modify the views of those who would draw very sharp lines, upon the ground of fossils alone, between marine sedimentary and other deposits. Also ripple-marks made by the winds, and as perfect as are ever formed by the waters, were found covering considerable areas in the sands high above the sea.

ART. LXIV.—*Cause of the apparently perfect cleavage in American Sphene (Titanite)*; by GEO. H. WILLIAMS.

MANY minerals, like diallage, bronzite, sanidine, etc., are known to possess a "parting" (German *Absonderung*) in certain directions which is essentially different from a true cleavage. This may be due to interrupted growth of the crystal, to regularly arranged inclusions or to other causes not always easy to explain. Professor G. vom Rath of Bonn has recently demonstrated that the very perfect parting, which exists in some varieties of pyroxene parallel to the basal pinacoid, is produced by the interposition of exceedingly thin twinning lamellæ.* These are so very narrow ($\frac{1}{8}$–$\frac{1}{4}^{mm}$) that they were for a long time entirely overlooked. This structure is especially characteristic of the salite occurring so abundantly in northern New York and Canada, and seems always to be due to the same twinning lamellæ which vom Rath first observed in crystals of diopside from Achmatowsk in the Urals.

In hornblende such a parting parallel to the basal plane is very exceptional, although it is has been observed by the writer in certain dark brown crystals from South Pierrepont, St. Lawrence Co., N. Y. It is here also due to the presence of twinning lamellæ as in the case of salite. The same parting produced by twinning lamellæ inserted parallel to the faces of the

* Zeitschrift für Krystallographie, v, p. 495. 1881.

fundamental rhombohedron is well known in corundum and hematite crystals from many localities.

During his recent visit to this country, Professor vom Rath suggested to the writer that the apparently perfect cleavage so often observed in the American sphene might be due to precisely the same cause, and such indeed upon investigation turns out to be the fact.

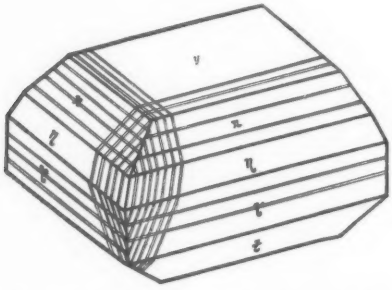
The cleavage of sphene is variously given by different authors, and seems not to be at all constant in specimens from different localities. As early as 1840, Professor C. U. Shepard figured and described crystals from Natural Bridge, Lewis Co., N. Y., and from Grenville in Canada, upon which two apparently perfect cleavages were observed meeting at an angle of 123° 30′, or as afterward more accurately determined by Brooke, 125° 30′. The somewhat abnormal habit of these crystals together with this cleavage seemed to Professor Shepard a sufficient ground for designating them as a new species, which he did under the name of *lederite*.* In speaking of the "Gelbmenakerz" of Werner, a massive variety of sphene from Arendal in Norway, Professor Quenstedt says: "Ihr Aussehen erinnert an Spatheisenstein, allein wir haben nur zwei blättrige Brüche, die sich etwa unter 125° schneiden, aber mehr schaligen Absonderungen gleichen."† The same cleavage angle (125½°) is also given by Blomstrand as occurring in the variety of sphene from Småland, Sweden, recently named by him alshedite.‡

The sphene which occurs so abundantly in this country associated with various silicates or with apatite in the limestones of the Laurentian, is almost always of a chocolate-brown color, and shows when in distinct crystals the habit of the variety called by Shepard lederite, (see figure). Whenever anything resembling a cleavage is present, the surfaces meet under the angle given above, corresponding to that of the pyramid $-4P$ (according to Dana). This is, however, not a true cleavage but a parting caused by repeated twinning, as in the case of salite.

That the exact position of these lamellæ may be better understood, a figure of a crystal of the lederite type is here given with the following table of the different symbols assigned to the planes by G. Rose,§ Des Cloizeaux,‖ and Professor J. D. Dana.¶

* This Journal, I, xxxix, p. 357. 1840.
† Handbuch der Mineralogie, 3d ed., p. 440. 1877.
‡ Dana, Syst. Min., III Appendix, p. 122.
§ De Sphenis, etc. Inaug. Disser., Berlin, 1820.
‖ Manuel de Min., i, p. 146. 1862.
¶ Syst. Min., 5th ed., p. 384. (The signs of the hemipyramids are changed to accord with general usage.)

Rose.		*Des Cloizeaux.*		*Dana.*	
$P\infty$	(y)	$0P$	(p)	$0P$	(O)
$\frac{2}{3}P\grave{2}$	(n)	$-P$	($d^{\frac{1}{2}}$)	$-2P$	(2)
$\frac{4}{5}P\grave{4}$	(η)	$-2P$	($d^{\frac{1}{4}}$)	$-4P$	(4)
$P\grave{\infty}$	(r)	∞P	(m)	∞P	(I)
$-2P\grave{2}$	(t)	P	($h^{\frac{1}{2}}$)	$2P$	(-2)



The face η is not common. It has been observed by Des Cloizeaux on greenovite, the manganese sphene from St. Marcel, Piedmont,* and by Hessenberg on crystals from Pfitsch in Switzerland.† It is also present on several crystals of the lederite habit in my possession, occurring with apatite in a red calcite near Eganville, Renfrew Co., Canada. This face lies in the zone $y:r$ and makes with y an angle of 130° 27′—(calculated 130° 45′ (Des Cl.)). In one of the crystals showing this plane the parting is exceptionally well developed; and the simultaneous reflections from both the crystal plane and parting surface shows that they are exactly parallel.

The most perfect development of this parting which I have anywhere observed is in the silvery-brown sphene, associated with the white microcline and green malacolite from Pitcairn, St. Lawrence Co., N. Y. These minerals are found imbedded in a coarse grained calcite and all have their faces and angles so rounded that accurate crystallographic determinations are very difficult. The malacolite shows a perfect parting parallel to $0P$. In the sphene the parting is, as a rule, much more perfectly developed parallel to one pyramid face than it is parallel to the other. After a number of trials such pieces were obtained as gave equally distinct reflections from both surfaces and the angle between them was determined by measurement to be 125° 26′. The calculated angle, as given by Des

* Manuel de Min., i, pl. xli, fig. 245. 1862.
† Mineral. Notizen, No. 4, p. 18, figs. 14, 15, 18, 19. 1861.

Cloizeaux,* between $\eta \wedge \eta$ is 125° 42′, so that the agreement is as great as could be expected in consideration of the reflections never being perfectly sharp.

The frequent total absence of this parting in one portion of a crystal when it is highly developed in another part, as well as the fact that it is to be found parallel to only one of the two pyramidal faces, shows that it is not to be regarded as a true cleavage.

It is furthermore easy to convince oneself by a careful inspection of such crystals as show it most perfectly, that this parting is really due to repeated twinning. The interposed lamellæ are so narrow as to be readily overlooked. They run around the crystal in the direction indicated in the figure—though of course in much greater numbers—meeting the edge $r \wedge r$ at an angle of about 16°. On the crystals from Pitcairn especially, the lamellæ are sometimes broad enough to give bright reflections of their own, and in one case it was possible to measure the inclination of the face r to the lamellæ traversing it as 159° 17′. The truly hemitropic character of these lamellæ is best shown in polarized light. A section of a Pitcairn crystal cut parallel to one of the parting surfaces showed parallel bands, similar to those observed in calcite, when this mineral is twinned according to $-\frac{1}{2}R$. The width of these bands varies from $\frac{1}{8}$ to $\frac{1}{30}$ of a millimeter, each one frequently appearing to be made up of innumerable narrower ones. They often change in width and sometimes either pinch out gradually or suddenly disappear. No accurate measurements of the angle of extinction of these bands could be made on account of the very high refractive index of the mineral.

There seems, therefore, to be little doubt that the apparently perfect cleavage, so characteristic of much of the American sphene is produced by a polysynthetic twinning parallel to the face η ($= -4P$ Dana, $-2P$ Des Cloizeaux, $\frac{4}{5}P\bar{4}$ Rose), a fact that is of interest as well for being a new twinning law for this mineral as an explanation of its characteristic parting.

In light of the recent investigations by Mügge,† Förstner‡ and others, on the production of secondary twinning lamellæ by pressure, it seems not improbable that the above described structure in sphene may be also due to the same cause. This seems the more likely since all the other minerals associated with the sphene from Pitcairn, in which the parting is most perfectly developed, show in a greater or less degree effects of the same kind. The calcite in which all the minerals are

* Manuel de Min., i, p. 148, 1862.

† Neues Jahrbuch für Min., etc., 1883, i, p. 32; ib., ii, p. 13; ib., 1884, i, p. 216.

‡ Zeitschrift für Krystallographie, vol. ix, 351, 1884.

imbedded always has polysynthetic lamellæ parallel $-\frac{1}{2}R$, the green malacolite has a very perfect parting due to twinning lamellæ parallel $0P$, while even the white feldspar crystals (microcline) possess in the greatest perfection that peculiar microperthitic interlamination of albite substance which Lehmann has also ascribed to the action of powerful pressure.*

Petrographical Laboratory, Johns Hopkins University, March 26, 1885.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Report on the results of an investigation as to the chemical methods in use for the determination of organic matter in potable water;* by Professor J. W. Mallet, F.R.S., University of Virginia (forming appendix D to the Annual Report of the National Board of Health for 1882, pp. 189–353, with 48 tables and several wood-cut figures).—A preliminary report on the general results of this investigation was published by the National Board of Health some three years ago, but the full report has but recently appeared, giving all details as to the kinds of water examined, the analytical methods investigated, the tests to which these were subjected, the results obtained, and the conclusions reached from these results.

The specimens of water examined — 161 in number — were grouped under the following heads:

Class I.—Natural waters, believed from actual use to be of good, wholesome character, including the regular water supply of some of the principal cities of the United States.

Class II.—Natural waters which there seems to be fair ground for believing have actually caused disease on the part of those drinking them. A request for information as to such waters, and for samples of them, was published for several months in the National Board of Health Bulletin, and was extensively copied into newspapers and professional journals, and a copious correspondence with physicians and others in various parts of the country was employed to secure such samples and to sift the evidence as to the supposed connection of each water with the production of disease.

Class III.—Natural waters of doubtful but more or less suspected character. In reference to these the medical evidence was insufficient to justify placing them in class II.

Class IV.—Artificially prepared waters, made by adding to good, wholesome water, determinate amounts of various infusions of *vegetable* organic matter, of natural origin, and of such kinds chiefly as water for human consumption is liable to come in contact with.

* Untersuchungen über die Entstehung der altkrystallinischen Schiefergesteine. Bonn, 1884, p. 217.

Class V.—Artificially prepared waters, made as above, with various forms of *vegetable* refuse from manufacturing or industrial operations.

Class VI.—Artificially prepared waters, as above, made with *animal* (or partly animal) organic matters of natural origin, especially such as are likely to occur in connection with the contamination of drinking water.

Class VII.—Artificially prepared waters, as above, made with *animal* refuse from manufacturing or industrial operations.

Class VIII.—Artificially prepared waters, as above, to which had been added morbid products from certain diseases in the human subject.

Class IX.—Solutions, in distilled water, of carefully determined amounts of pure organic substances of definite chemical composition.

The three methods, with various modifications of the same, for the determination of organic matter which were investigated were:

(1) The "combustion process" of Frankland and Armstrong; (2) The "albuminoid-ammonia process" of Wanklyn, Chapman and Smith; and (3) The "permanganate process," originally suggested by Forchhammer, in the forms advocated by Tidy and Kubel respectively.

The specimens of water, supplied under precisely similar conditions, were simultaneously examined by these methods in the hands of three independent analysts, well trained for the work, one in Baltimore, one in Washington, and one at the University of Virginia—all quite ignorant of the history and character of the specimens submitted to them, these specimens being designated solely by an arbitrary series of numbers.

At the same time a microscopic examination of each water was made and a pathological investigation of its effect (when concentrated by evaporation at very low temperature) upon rabbits by hypodermic injection, under the direction of Professor H. Newell Martin, of the Johns Hopkins University.

A detailed criticism of each of the methods examined is given, noticing the special advantages and defects of each, with suggestions for the practical modification of these methods with a view to their improvement.

The chief interest of this report in its complete form consists in the study by comparison with each other of the results given in the series of tables, illustrating pretty fully the bearing of the different conditions involved—character of water examined, state in which its organic matter was present when examined, precise conditions of application of the methods used, different character of the results deducible from each of these, etc.

The most important general conclusions arrived at as to the value for sanitary purposes of the different processes studied are the following:

(1.) It is not possible to decide absolutely upon the whole-

someness or unwholesomeness of a drinking water by the mere use of any of the processes examined for the estimation of organic matter or its constituents.

(2.) In judging the sanitary character of a water not only must such processes be used in connection with the investigation of other evidence of a more general sort, as to the source and history of the water, but should even be deemed of but secondary importance in weighing the reasons for accepting or rejecting a water not manifestly unfit for drinking on other grounds.

(3.) There are no sound grounds on which to establish such general "standards of purity" as have been proposed looking to exact amounts of organic carbon or nitrogen, "albuminoid-ammonia," oxygen of permanganate consumed, etc., as permissible or not. Distinctions drawn by the application of such standards are arbitrary and may be misleading.

(4.) Two entirely legitimate directions seem to be open for the useful examination by chemical means of the organic constituents of drinking water, namely: first, the detection of *very gross* pollution, such as the contamination of the water of a well by accidental bursting or crushing of soil-pipes, leakage of drains, etc.; and secondly, the periodical examination of a water supply, as of a great city, in order that, the normal or usual character of the water having been previously ascertained, any suspicious changes which from time to time may occur, shall be promptly detected and their cause investigated.

(5.) In connection with this latter application of water analysis there seems to be no objection to the establishment of *local* "standards of purity" for drinking water, based on sufficiently thorough examination of the water supply in its usual condition.

(6.) The facts of this investigation tend to show that special and very great importance should be attached to a careful determination of the nitrites and nitrates in water to be used for drinking. No aspect in which the good and bad natural waters have been compared has afforded so definite a result as this.

(7.) In watching a large city water supply use should be made of all three of the principal processes for the examination of the organic matter present; each gives a certain kind of information which the others do not afford. Under circumstances admitting only of the use of simple means of investigation, the albuminoid-ammonia and permanganate processes might be employed together, but in no case should one only of these methods be resorted to, such a course entailing practically the neglect of carbon on the one hand or nitrogen on the other.

Among the more interesting special conclusions reached may be quoted the following:

(1.) Distinct proof has been obtained that in the "combustion process" there are two constantly present errors, varying but usually important in amount, namely: loss of carbon during the evaporation of the water, and gain of nitrogen from ammonia in the atmosphere surrounding the gas flame, the latter probably

partly balanced by loss of nitrogen originally present in the water.

(2.) It has been shown that within a practically reasonable time enough water for the application of the combustion process may be evaporated in a closed vessel and under greatly reduced pressure at a temperature but little over 30° C., and that decidedly improved results may be obtained by thus modifying the process.

(3.) In regard to the Wanklyn "ammonia process" it has been ascertained that in the determination both of "free" and "albuminoid" ammonia there is a loss, sometimes quite considerable in amount, resulting from imperfect condensation of the ammonia during distillation.

(4.) In the application of the same process it has been proved that in some cases nitrogenous organic matter is volatilized during the distillation for "free" ammonia, and the amount of so-called "albuminoid" ammonia thus made to appear less than it should be.

(5.) As regards the "permanganate process" it seems that the amount of oxygen consumed by a specimen of water is probably in all ordinary cases much below that required for complete oxidation of the organic matter present, and does not stand in any fixed ratio thereto. It cannot be taken as a measure either of the organic carbon or of the total organic matter, though a distinct general resemblance can be traced between strongly marked results, high or low, as the case may be, for the consumption of oxygen on the one hand and organic carbon (by the combustion process) on the other.

(6.) The conclusions commonly drawn from the ratio of carbon to nitrogen in the organic matter of water as to this organic matter being of *vegetable* or *animal* origin may in some cases be quite erroneous. Thus, for instance, this ratio would in the case of water contaminated by the alkaline washings from the manufacture of starch, lead to the belief that animal matter was present, while in water to which an infusion of human fæces had been added the ratio in question would indicate vegetable impurity.

(7.) The biological experiments (on rabbits) serve to show that the general belief in the greater danger arising from the presence of animal rather than vegetable organic matter in water is not to be accepted without qualification or exception. Most strongly marked pathological effects were produced (and verified by repetition) by water to which there had simply been added an infusion of dead forest leaves, such as is washed away in immense quantity in autumn and winter from the surface of any woodland country.

(8.) The very small absolute amount of organic matter indicated as present in many of the most dangerous waters examined furnishes evidence against any purely chemical theory of the production of disease from this source, and tends to support the

belief that not to the direct effect of any chemical substances (such effect necessarily standing in definite relation to their quantity), but to the presence of living organisms with their power of practically unlimited self-multiplication, we must in all probability look for an explanation of most at any rate of the mischief attributable to drinking water. At the same time it is of course possible that indirectly a large amount of organic matter in water may be more dangerous than a smaller quantity, as furnishing on a greater scale the suitable material and conditions for the development of noxious as well as harmless organisms.

(9.) The biological experiments indicated by some of their results, not only the probability that the pernicious character of certain waters was referable to the presence and action of living organisms, but also the possibility that a water containing organic matter of any kind may be harmless at one time and harmful at another, when perhaps a different stage of fermentative or putrefactive change may have been entered upon, and special organisms may have made their appearance or entered upon a new phase of existence.

The Report is marred by some typographical errors arising from its being printed without the proof-sheets having been submitted to the author for correction. The most important mistake in the printing consists in the "general discussion of results" being given first as a reproduction of the preliminary report, instead of appearing in proper place at the end of the main report; all the matter from the lower part of p. 190 to p. 211 inclusive, should be transferred so as to come immediately before p. 307.

Those who may desire to see the Report itself should apply to W. P. Dunwoody, Esq., Secretary of the National Board of Health, Washington, D. C.

2. *Radiation from incandescent lamps.*—Crookes, from the result of experiments on the radiation from thermometer-bulbs in high vacua, has concluded that at pressures between forty millionths and one millionth of an atmosphere the radiation varies as the mean molecular free path. Captain Abney lately communicated to the Physical Society of London the results of experiments upon the radiation from incandescent electric lamps contained in thin glass bulbs. It was found that from forty millionths to ten millionths of an atmosphere the radiation increases uniformly with decrease of pressure, but beyond this point it becomes nearly constant. The amount of radiation for any ray of the spectrum was then determined by means of a thermopile, and the result was then plotted, with watts as abscissæ and radiation as ordinates. The curves for each kind of ray were found to be hyperbolas with vertical axes. The result gave a method for rendering identical the quality of the light emitted by any two lamps. The radiation is found for any particular ray, and by examining the curve corresponding to that ray from the other lamp one can find for what number of watts the radiation is the same.—*Nature*, April 2, 1885, p. 523. J. T.

3. *Measurement of low temperatures.* — M. WROBLEWSKI has compared the indications of a hydrogen thermometer and a thermal junction. The hydrogen thermometer indicates, below −193° C., temperatures lower than the thermal junction, which shows that hydrogen below the above temperature contracts more than the laws of Mariotte and Gay-Lussac demand. This departure increases with the depth of temperature. Thus the hydrogen thermometer gives for the temperature of solidification of oxide of carbon and azote −207° C. and −214° C. The thermal junction gave −199° C. and −203° C. The regularity of the thermo-electric curve shows that the thermal junction gives more reliable indications than the air thermometer at very low temperatures. When oxygen, azote, and oxide of carbon are evaporated in a vacuum the temperature falls only a few degrees below −200° C. The author also maintains that the law of liquefaction of atmospheric air is not that of a simple gas; but acts like a mixture of which the components have different laws of liquefaction.— *Comptes Rendus*, April 13, 1885, p. 979. J. T.

4. *New property of Selenium.*—WERNER SIEMENS has examined the new selenium cells made by Mr. Fritts, of New York, and states that they possess great sensitiveness to rays of light of certain refrangibility. These cells consist of a thin homogeneous layer of selenium spread on a metal plate. This layer is heated to convert it from amorphous to crystalline selenium, and is then coated with fine gold leaf. One of the plates examined by Siemens was not sensitive to light; when, however, a galvanometer was intercalated between the gold leaf and the base plate, the existence of an electrical current was detected. The difference of potential was apparently proportional to the light, and it remained during the illumination. The infra-red rays did not produce this difference of potential. This electromotive force increased from 9.30 A. M. to 11.35 A. M.; remained constant for some time, and then decreased to 3 P. M.—*Sitzungsberichte der Akad. der Wissen. zu Berlin*, Feb. 12, 1885. J. T.

5. *On the depth in the sea to which light penetrates.*—MM. H. LOL and ED. SARASIN, who have studied the absorption of light by the water of Lake Geneva, have extended their researches to the water of the Mediterranean. The photographic plates, which were lowered to different depths, were protected from the action of salt water by a bituminous varnish, which was removed by spirits of turpentine and alcohol before the plates were developed. The authors conclude from their experiments that during the month of March, at midday and under a clear sky, the diurnal rays are arrested at a depth of 400^{m}.— *Comptes Rendus*, April 13, 1885, pp. 991–994. J. T.

6. *Thermo-electric piles.*—The Clamond battery is constructed of couples of iron or nickel and an alloy of antimony and zinc. M. Clamond and M. Carpenter have lately greatly increased the efficiency of this battery. One model consisting of 120 elements gave 8 volts and had an internal resistance of 3·2 ohms; another

of 60 elements gave 3·6 volts with an internal resistance of 0·65 ohms. The amount of gas consumed by both models was 180 liters per hour.

II. Geology and Mineralogy.

1. *International Geological Congress.*—The third session of the International Geological Congress will be opened at Berlin on the 28th of September, under the honorary presidency of Dr. H. von Dechen, and will continue to October 3d. Geological excursions will occupy from the 5th to the 10th of October. Those intending to be present should announce it soon to the secretary of the Committee of Organization, Berlin, No. 44 Invalidenstrasse, with a mention of residence and position. The fee for new members, 12 francs, may be sent with the letter announcing the proposed attendance.

2. *Pennsylvania Geological Atlas of Counties.* — Professor Lesley, the Director of the Geological Survey of Pennsylvania, has published, in *octavo* form, an atlas of County geological maps, sixty-seven in number and admirable in all respects, together with introductory text containing a general account of the several counties both topographical and geological. It is exceedingly gratifying to have such an example of geological maps on a convenient scale for use, and maps that contain, in most cases, all the details that are ordinarily desired.

3. *Massive Safflorite.*—In a letter to the Editors, dated May 3d, Mr. L. W. McCay states that to avoid misunderstanding two incomplete sentences in his article upon massive safflorite, on p. 370 of the May number, should read as follows: "He further appears to doubt the accuracy of the statement which appears so often in Breithaupt's Paragenesis to the effect that speiskobalt and safflorite appear together, *the former above the latter*, and suggests it as well to examine the specimens belonging to the Freiberg collection with a view of discovering what this safflorite really is. The specimens from Bieber, Schneeberg, Reinerzau and Wittichen, which Sandberger had opportunity to examine, exhibited no indications of the two minerals occurring together *as stated.*" The interpolations requisite for a proper understanding are in italics.

4. *The Santa Catharina Meteorite;* by Orville A. Derby. —Subsequent examination, which unfortunately could not be communicated to this Journal in time to prevent the publication of the note in the January number, shows that the observations there recorded were based on errors of identification of the elements of the stony crust that envelops fragments of the meteorite. This crust proves to be due to the cementation to the iron of the elements of the soil and disintegrated rock on which it rests, but so altered in physical aspect and chemical composition that with the imperfect means of separation then at command and my limited experience in dealing with partially altered and reconstituted rocks, I was completely deceived regarding its true nature and relations to the meteoric mass.

III. Miscellaneous Scientific Intelligence.

1. *Concours National de Compensation de Chronomètres pour les températures;* by G. Cellérier. Geneva, 1885.—The competition, the results of which are discussed in this volume was initiated by the section of Horology of the Society of Arts, Geneva. Fifty-four pocket and seven marine chronometers were in the competition, and an uncompensated marine chronometer was added for purposes of comparison.

It is well known that a chronometer with an uncompensated balance wheel may be regulated to keep time for any one given temperature. With a compensated balance wheel the chronometer can be regulated to keep correct time at any two given temperatures. But experience shows that, in general, the chronometer thus adjusted will not keep correct time at other temperatures than those two. Fifty years ago Dent expressed this by saying: that between the two given temperatures the chronometer gains time, that above the higher and below the lower temperatures the chronometer loses time. This *secondary* error of compensation, or *Dent's inequality*, is sometimes expressed thus: *The curve whose abscissas are the temperatures and whose ordinates are the corresponding rates is a parabola.* A goodly number of mechanical devices have been tried, at large expense of time and money, generally with indifferent success, for the purpose of correcting this peculiar irregularity. Yet strange to say the present investigation is, we believe, the first extensive one for ascertaining the facts about this inequality. It gives us a large number of observations. M. Cellérier has obtained from them some important conclusions.

Some chronometers had steel spiral springs and some had palladium. The whole were kept at a temperature as near to 5° Centigrade as practicable for five days, then in like manner for successive periods of five days each, the temperatures were 10°, 15°, 20°, 25°, 30°, 35°, 30°, 25°, 20°, 15°, 10°, 5°, 35°; that is, fourteen periods in all. Between each two periods one day was omitted to allow the warm box and the time-pieces to assume throughout the new temperature. In the final discussion the last period was discarded. The position throughout was dial up.

In the competition of the time-pieces four observed elements were considered: the average daily error, the average difference of rate in the two isothermal periods, the average error per degree in the correction of the primary inequality, and the average secondary error. But the principal scientific interest of the work consists in the facts and discussions about the secondary inequality.

The pieces that had palladium springs were compared with those that had steel springs, with the following results. Upon plotting the curves to present the observed secondary error those of the palladium springs had no really typical form. They were sinuous and of varied shapes but of small amplitude. On the other hand the curves for the steel springs were much more inclined to a parabolic form, but had greater amplitudes. In short, steel springs in the hands of a good adjuster permit us to

know by a simple formula the rate of the chronometer, while palladium springs give smaller but more irregular secondary errors. The average of the secondary errors for palladium springs was about 70 per cent of that for steel springs. If these five points of merit be taken together, viz: regularity of daily rate, identity of rate in isothermal periods, smallness of principal error of compensation, smallness of secondary error, and regularity of secondary error, the author says that the steel and the palladium springs stand on an equality.

The mean acceleration for the first seven periods differed from that of the last seven. The curve for the secondary error also differed very decidedly in the two periods. In general it approached much more nearly to the parabola in the second than in the first half of the time. The cause of this is supposed to have been that most of the time-pieces had been adjusted only a short time before the trial, and therefore had not in the earlier periods attained such regularity of action as in the later periods.

The bulletins of daily rate, with the reductions, are given in full, and the various curves for the secondary errors are presented in the plates. These curves of course include all errors of observation of unknown irregularities. The facts developed by this competition cannot fail to throw light on the unknown causes of the secondary error. N.

[Copies of this memoir may be obtained from Mr. Florend, 15 Maiden Lane, New York City; the price is 20 francs.—EDS.]

2. *Annals of the Astronomical Observatory of Harvard College;* vol. xiv, Pt. II.—Observations with the Meridian Photometer during the years 1879–1882, by EDWARD C. PICKERING, Director, aided by Arthur Searle and Oliver C. Wendell, Assistants in the Observatory. pp. 327–512. Cambridge, 1885.—The first portion of this important work on Astronomical Photometry, embracing the observations with the Meridian Photometer at the Harvard Observatory, is contained in Part I of volume xiv, and was briefly noticed in this Journal at the time of its publication (xxviii, 319). Part II, now issued, contains a comparison of the results of the Harvard observations with the catalogue of Ptolemy, with those of both Herschels, and with all the modern catalogues which give estimated or measured magnitudes of stars. The Suspected Variables, Discordant Observations, the Distribution of Stars, and Errors of Catalogues are subjects of separate chapters.

3. *Thunder Storms.*—The New England Meteorological Society has issued a circular containing an announcement of a special subject of investigation for the summer of 1885, with advice, which will be sent to all desiring it on addressing Professor W. M. Davis, Secretary of the society, Cambridge, Mass., together with instructions and blanks for records. The council of the society asks the assistance of members and observers, and of all persons interested in this investigation, not only in keeping records but particularly in extending the observers in their neighborhood.

4. *Van Bemmelen.*—In the last number of this Journal, on page 422, Van Beneden is a typographical error for Van Bemmelen.

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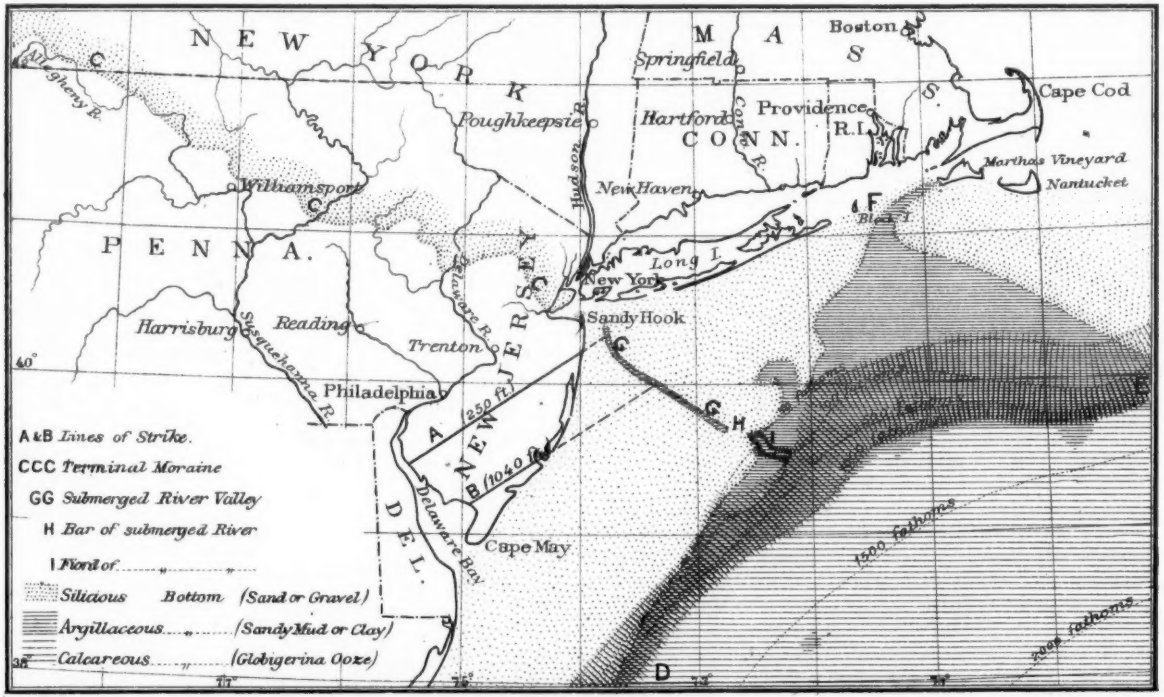
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